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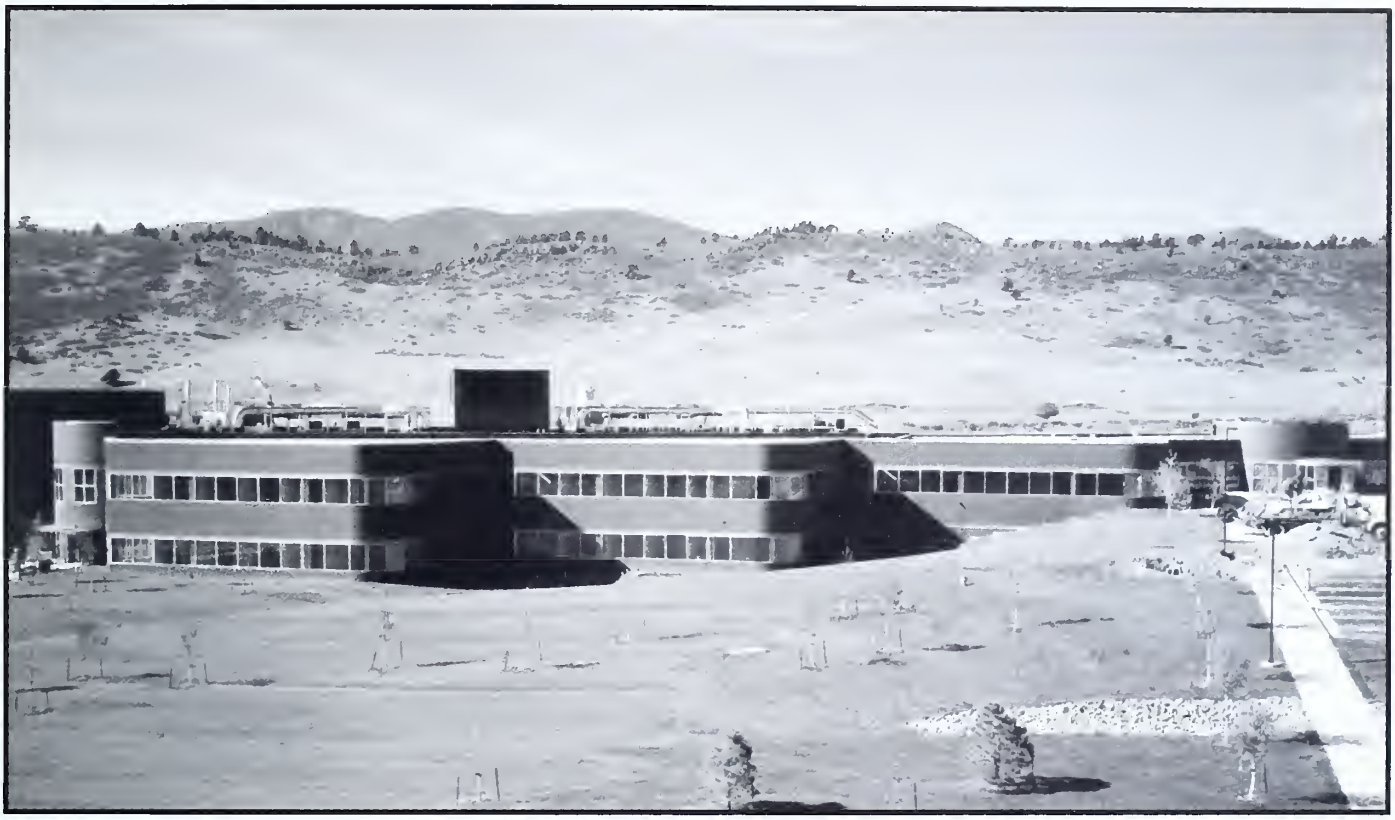
INTRODUCTION

Wildlife Services— Vision and Strategic Goals



The mission of Wildlife Services (WS) is to provide Federal leadership in managing problems caused by wildlife. The National Wildlife Research Center (NWRC) functions as the research arm of WS by providing scientific information for the development of socially acceptable methods for wildlife damage management. As part of WS' strategic plan to improve the coexistence of people and wildlife, it has identified four goals: (1) Developing Methods, (2) Providing Wildlife Services, (3) Valuing and Investing in People, and (4) Information and Communication. WS is dedicated to helping meet the wildlife damage management needs of the United States by building on the unit's strengths in these four key areas. This annual NWRC Research Highlights is structured around these program goals. NWRC has 18 multiyear research projects to address the current needs of the program and its customers in these 4 areas.

New Laboratory and Office Building—In January 1999, NWRC staff in Fort Collins, CO, moved from three temporary buildings into a new headquarters laboratory and office building, the NWRC Wildlife Services Building, located on 43 acres on the Foothills Research Campus of Colorado State University (CSU). The new building houses all NWRC staff in Fort Collins except for the Animal Care staff, who are located in the adjacent NWRC Animal Research Building (ARB). The combination laboratory and office building was constructed by a private developer and is leased to NWRC. The building comprises 71,000 ft^2 of space, including specialized laboratories for bird, mammal, product development, and chemistry research along with other unique spaces for the research library, record and tissue archives, a conference center, and office space for 100 NWRC staff, visiting scientists, and students.

The next phase of the master plan for this site also is under way. It includes construction of outdoor animal holding facilities and the ARB support wing. These facilities should be completed by the year 2000. Some additional construction will still be needed to complete the master plan.

DEVELOPING METHODS

Goal: Increase effective methods available for wildlife damage management.

BIRD RESEARCH PROJECTS

Title: Management Strategies To Reduce Bird Problems in the Western United States

Goal: Develop safe and effective methods to reduce bird problems in the Western United States.

Impacts of Canada Goose Movements on Aircraft at Elmendorf Air Force Base, Anchorage, AK—Bird strikes to aircraft are a serious economic and safety problem in the United States, annually causing millions of dollars in damage to civilian and military aircraft and the occasional loss of human life. A significant military aircraft disaster caused by birds occurred in 1995 at Elmendorf Air Force Base (EAFB) in Anchorage, AK when an E–3 Sentry Airborne Warning and Control System aircraft ingested several Canada geese on takeoff and crashed, killing 24 people. NWRC scientists have been helping to resolve these kinds of problems for several years.

During 1998, NWRC scientists identified geese that frequent EAFB, ascertained movement patterns of goose concentrations in the Anchorage area, identified goose feeding and loafing sites, obtained data on the relationship between their distance and movements onto EAFB, and determined the efficacy of goose translocation. With respect to evaluating translocation, 1,236 lesser Canada geese were fitted with coded plastic neck collars and observed between August and October 1997. These geese were collared at 16 molting sites located throughout the Anchorage area. EAFB dispersal teams and NWRC personnel observed 208 collared geese, at least once, inside the EAFB exclusion zone.

Twenty-six percent of the collared geese observed on EAFB had previously been translocated about 60 km away. Of these, 41 were observed more than once. In addition, 23 percent translocated to Anchorage International Airport and 38 percent translocated to Merrill Field Airport also returned multiple times following hazing.

These geese present a special hazard to aircraft safety because they appear to have become habituated to nonlethal scare tactics. In addition, collared geese first moved back to EAFB 30 to 40 days after capture, and the largest proportions return between 70 and 90 days after capture. Return rates of the other relocated geese ranged from 75 to 100 percent for adults, and 96 to 100 percent for juveniles. Translocations provided only short-term relief in reducing risks to aircraft safety.

Mesurol® and Flight Control® Show Promise in Reducing Horned Lark Damage to Lettuce Seedlings— Lettuce is an important economic crop in California, with approximately 77,000 ha in production and a value of $735 million in 1996. Bird damage to recently planted crops is a major problem in several of California's lettuce-producing areas, including the San Joaquin Valley, the central coast, and southern California. Annual losses due to bird damage at seedling emergence is estimated at $4.6 million. The bird species primarily responsible is the horned lark. The current method used to reduce these losses is hazing by shooters, a method that provides a questionable level of protection. Two products, methiocarb (Mesurol) and anthraquinone (Flight Control), have shown promise as bird repellants. Both compounds were evaluated for repellancy to horned larks when applied on newly sprouted lettuce seedling in a field setting. Both compounds were equally effective and resulted in significantly less damage than occurred in control fields. Larger scale field testing of both products is planned in 1999.

Field Evaluation of Silt Fencing to Discourage Gull Nesting—Gull populations in the Columbia River basin have been implicated in depredations to migrating endangered salmon smolt. Gulls nest on several islands near this resource. Silt fencing, a woven black polypropylene material, appears to discourage nesting gulls from these islands and to disperse the populations. The fencing was evaluated on Cabin Island, located above the Priest Rapids dam, Grant County, WA, and Upper Nelson Island located near Richland, Benton County, WA. The fencing was placed in parallel rows spaced 10 m apart within the nesting colonies. Preliminary results showed that the fencing, when used at a site with 3 previous years of egg oiling, reduced gull nesting by 89 percent (from 2,462 nests in 1997 to 261 nests in 1998). At the second site, results were inconclusive because high winds and unstable soil conditions collapsed the fencing. Further evaluation on the use of silt fencing as a gull nesting deterrent is warranted.

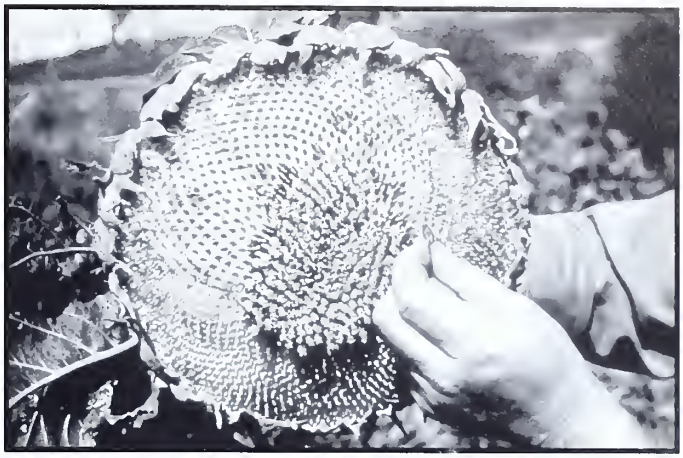
Bird Aircraft Strike Hazards at Naval Air Station North Island, San Diego, CA—Birds present a direct hazard to aviation safety at Naval Air Station North Island (NASNI), San Diego, CA. NWRC biologists documented 27 bird–aircraft strikes on NASNI from April 1996 to April 1997. Of these, western gulls caused 77 percent, mallards 9 percent, American coots 5 percent, and great blue herons 5 percent. Other strikes were caused by barn swallows, ravens, and lesser scaup. Most strikes that occurred between March and September were attributed to western gulls, whereas strikes between October and February were attributed to waterfowl. The Command Navy Safety Center in Norfolk, VA, reported 102 bird strikes to aircraft at NASNI between 1980 and 1996. About half those strikes occurred during landing. The strike reporting rate is believed to be about 30 percent.

Bird-use patterns on NASNI varied by species, time, and location. Thirty-three species were identified on the airfield. The greatest bird activity occurred during May, with daily counts of approximately 1,600 birds—mostly western gulls. Waterfowl, specifically mallards and American coots, peaked during December and January. Western gulls, great blue herons, starlings, mourning doves, and pigeons made up about 96 percent of all birds observed crossing runways.

To understand bird movements in the area better, NWRC scientists color-marked 800 western gulls and fitted 12 others with satellite transmitters. Observations of color-marked gulls indicated that they dispersed to a number of other loafing or roosting sites away from NASNI. Of 650 gulls color-marked on NASNI, only 23 were observed at any 1 time at the Station, suggesting a high turnover rate of gulls. During the study period, 888 telemetry readings were obtained from the 12 western gulls fitted with satellite transmitters. Most of the gulls dispersed to other locations. Only 3 of 12 gulls consistently used NASNI. Overall, only 8–10 percent of the telemetry readings were on NASNI. The greatest distance a gull dispersed from NASNI was 800 km, to Monterey, CA.

Title: Management Strategies To Control Blackbird Damage in the United States

Goal: Reduce the magnitude of health, safety, and nuisance problems caused by blackbirds and improve agricultural production by reducing blackbird depredation losses in citrus- and fruit-producing enterprises and in sprouting and ripening corn, sunflower, rice, and other grains.



Blackbird Population and Damage Surveys in the Dakotas—NWRC scientists are attempting to establish baseline data on breeding blackbird densities and damage to sunflower. During 1996 and 1997, the breeding blackbird population in Stutsman County, ND, averaged 22 pairs per 65 ha or approximately 199,000 pairs in the county. Each pair produces about 2 young, potentially swelling the county population to about 796,000 birds by late summer.

From 1994 to 1996, bird damage surveys were conducted within Stutsman County. Average annual crop damage within the townships was about 2.4 percent by volume. If one assumes an annual average production of about 200 million lb of sunflower in the county, the birds ate about 4.8 million lb of sunflower per year, valued at $480,000.

In future years, intensive breeding bird and damage surveys will be conducted in four counties in North Dakota and South Dakota. These data may be used to measure the efficacy of various damage abatement programs, to identify high-damage areas, and to establish the relationship between bird densities and damage levels. Acceptance of DRC–1339-treated rice baits by blackbirds continues to be a major problem. NWRC researchers tested a seed coating consisting of various clays and found it to deteriorate within 1 to 2 days in Louisiana's humid weather. Furthermore, blackbirds did not eat the coated rice seeds. Other coating materials will be tested in the future.

In another study, investigators determined local and migratory movement patterns for four blackbird roosts in Louisiana. Most blackbirds forage within 6 km of their roost, but some may move 60 km to feed. Birds marked in Louisiana before spring migration were found breeding in the Great Plains and Canada, indicating that some blackbirds damage both sunflower and rice.

Title: Development of Management Strategies To Reduce Piscivorous Bird Predation at Aquaculture Facilities

Goal: Determine the magnitude of, and develop methodology to reduce bird predation on cultured aquaculture products, including catfish, baitfish, tropical fish, trout, and other finfishes.

Cormorant Food Habit Studies—With the recent success of large-scale cormorant roost harassment efforts in the delta region of Mississippi, more cormorants have shifted their foraging activity to oxbow lakes along the Mississippi River. Prompted by concerns about the possible impact of cormorants on sport fishing, NWRC biologists conducted a cooperative study with the Mississippi Department of Fisheries, Wildlife and Parks to evaluate the impact of cormorants on sport fish at a selected oxbow lake. Results of this food-habits study indicated that 87 percent of the diet by weight was shad, primarily gizzard shad, with most of the remainder (11 percent) consisting of bluegill. On the basis of cormorant numbers using the lake over a 4-month period, cormorants may have removed more than a million shad and a hundred thousand bluegill. However, the impact of cormorant predation on the overall sport fish industry may be minor.

The dramatic increase in the number of cormorants wintering in the Southern United States has coincided with the rapid rise of the catfish industry in this region. To determine whether the availability of commercially raised catfish has enhanced winter survival of cormorants and possibly contributed to this population increase, NWRC biologists compared the weights and body fat of cormorants collected in the delta region of Mississippi with those of cormorants collected in areas without catfish production. Cormorants collected on catfish farms were significantly heavier and had more body fat, suggesting that the availability of commercially raised catfish has resulted in improved overwinter survival and may have enhanced the breeding success of cormorants.

Wading Bird Predation on Catfish—Wading birds, primarily great blue herons and great egrets, are frequent visitors at catfish ponds in the delta region of Mississippi, and most farmers consider them to have a significant impact on catfish production. A previous study by NWRC biologists indicated that a typical catfish farm in the delta supported about 22 great blue herons, each of which consumed 12 4-inch fingerlings daily. In 1995, NWRC biologists examined wading-bird predation during an entire year throughout the delta region. Thirty pond complexes were surveyed every 4–6 weeks for wading-bird populations. Where wading birds were present, their rate of predation on catfish was determined. In addition, farm managers were interviewed to determine if the health or density of fish might influence wading-bird behavior. The data suggest that great blue heron populations have increased threefold over the past 5 years, and thus the average catfish farm now supports 78 herons and 56 great egrets. Catfish constituted only 8 percent of the diet of great egrets but 44 percent of the diet of great blue herons. However, recent pen studies suggest that herons are inefficient foragers on healthy catfish and that additional research is needed to clarify actual production losses.

Title: Management of Wildlife that Pose Hazards To Aviation

Goal: Develop safe and effective methods for reducing wildlife hazards to the air transport industry.

Research Provides Airports With New Tools for Reducing Bird Strikes—The collision of aircraft with birds, deer, and other wildlife is a serious problem at airports throughout the United States. Through an interagency agreement with the Federal Aviation Administration (FAA), NWRC is conducting research in several areas to better understand and reduce the strike problem.

As one example, WS undertook an experimental program to reduce gull collisions with aircraft at John F. Kennedy International Airport (JFKIA), New York between 1991 and 1997. In this program biologists stationed on airport boundaries used shotguns to shoot gulls flying over the airport. No nontarget species were affected, and no nontarget gulls (i.e., gulls not on airport property) were killed.

The program had a dramatic effect on bird strikes. The number of aircraft striking laughing gulls during the shooting period (May 20 to August 15) declined by 66 percent in 1991 and 76–89 percent in 1992–97 compared with numbers during the same time period for 1988–90. Strikes by other gull species were reduced comparably. NWRC scientists developed an aerial photography technique to monitor the effect that the shooting program had on the nearby laughing gull colony. Results indicated that shooting reduced the local population but did not significantly lower the regional or national gull populations.

Another research effort evaluated the Forward Looking Infrared (FLIR) system for nighttime detection of deer and other mammals on airport property. More than 350 civil aircraft collisions with deer have been reported in the United States since 1983, most of which resulted in serious damage to the aircraft. Detection of deer on airport property at night is critical to allow timely hazing of deer from runways and, from a long-term perspective, to develop, justify and evaluate deer management plans.

NWRC biologists compared the effectiveness of FLIR, spotlight, and night vision for detecting white-tailed deer at night in winter and summer 1997 at the National Aeronautics and Space Administration's Plum Brook Station, Erie County, OH. Biologists observed 20–70 percent more deer with FLIR than with spotlights or with night vision. In addition, 50 percent more raccoons were observed with FLIR than with the other devices.

This study indicates the FLIR system is the most effective means for nocturnal detection of deer at airports in summer and winter. In contrast to spotlighting, FLIR has the advantage of being unobtrusive. This characteristic should also make it an ideal monitoring aide for suburban deer populations. Moreover, FLIR may also prove useful for surveying raccoons.

Another major undertaking has been the management and analysis of FAA national data base on bird and other wildlife strikes with aircraft. Through an interagency agreement with the FAA, NWRC took over management of the FAA wildlife strike reporting system in 1995. Biologists now have over 19,000 strike reports between 1990 and 1998 edited and accurately entered into a National Wildlife Strike Data Base. Interpreting the forms, entering the data, and editing the data base have been tedious and complex undertakings, requiring personnel knowledgeable in birds, mammals, airports, and aircraft.

This data base is already proving to be invaluable in providing biologists, aeronautical engineers, and airport managers with specific information on strike histories for airports, aircraft and engine types, and regions of the United States. The data base allows biologists and engineers to better define problems by species, time of year, and other factors so that science-based management and preventative plans can be developed and evaluated. NWRC personnel have already handled more than 270 requests for information on bird strikes nationwide by biologists, engineers and aviation analysts. As more strike data are entered, the data base will become an even more powerful management, research and evaluation tool.

Effectiveness of Anthraquinone as a Grazing Repellant for Canada Geese and as a Seed-Treatment Repellant for Brown-Headed Cowbirds—NWRC scientists evaluated the effectiveness of a 50 percent active ingredient formula of anthraquinone (Flight Control) as a grazing repellant for Canada geese and as a seed-treatment repellant for brown-headed cowbirds in northern Ohio in 1997. In a turf test, 2.5 times more bill contacts were observed on untreated plots compared with treated plots during a 7-day test with captive geese. Mean numbers of geese per observation were also greater on untreated plots compared with treated plots. Residue analyses indicated that the solution declined from 2.02 kg/ha on turf at application to 0.22 kg/ha after 1 week. In the cowbird test, individually caged cowbirds were presented untreated millet or millet treated with the anthraquinone bait at various concentrations in one- and two-choice tests for 3 to 4 days. Flight Control was repellent to cowbirds at all levels in both one-and two-choice tests. Each group of treated birds in the one-choice test lost body weight, whereas the control group did not. Flight Control was an effective foraging repellant for Canada geese in a 7-day pen experiment and for brown-headed cowbirds as a seed repellant in aviary experiments.

Evaluation of U.S. Air Force Bird Avoidance Model—An NWRC biologist has been working with the U.S. Air Force (USAF) to reduce bird strikes to military aircraft. This is a very serious problem: since 1986, bird strikes have caused nearly $500 million in damage to USAF aircraft, and 33 people have been killed in bird-caused crashes. To reduce these losses, the USAF developed a Bird Avoidance Model (BAM) to evaluate low-level training routes for bird strike hazards throughout the contiguous United States. The current BAM, developed during the 1980's, incorporates waterfowl and raptor species, which collectively account for the majority of damaging bird strikes to military aircraft. Because changes have occurred to waterfowl and raptor populations throughout North America, there is speculation that the BAM (developed and currently run with historical waterfowl and raptor data) may not accurately predict bird strike hazards. Therefore, the NWRC biologist compared bird-strike hazards predicted by the BAM for those low-level routes where waterfowl and raptor strikes occurred with a random selection of published low-level routes where waterfowl and raptor strikes were not reported.

Mean predicted bird strike hazards for waterfowl and raptors were higher for routes where strikes had occurred than for routes where strikes by these species had not occurred. Thus, the BAM has successfully predicted mean bird strike hazards along low-level training routes for the military, and, when properly used, can assist with flight planning to minimize waterfowl and raptor strike hazards. From April 1996 to July 1998, the NWRC biologist has evaluated 2,500 training routes and areas for bird strike hazards for various military branches.

Title: Development of Nonlethal Chemical Repellants for Birds

Goal: Develop methodologies that contribute toward the discovery and practical development of nonlethal, environmentally benign chemical repellants for use in resolving conflicts between wildlife and agriculture and industry.

Integrated Hazing Systems for Birds—Effective nonlethal chemical repellants have been developed to protect commodities from being eaten by birds. However, these repellants require direct application to the surface of the resource to be protected, and birds must sample the material before they are repelled. This sampling leads to crop damage and, if the bird population is sufficently large, will result in unacceptable economic losses.

NWRC scientists, in cooperation with a CSU master's degree student, evaluated an integrated hazing system designed by Knight Piesold, Ltd., and employed at PacifiCorp's Jim Bridger Power Plant in Wyoming. The concept behind this system was to combine existing bird-control technologies into a system that would protect large areas (36- and 73-ha ponds) by preventing birds from landing on contaminated ponds for extended time periods. The system consisted of pyrotechnic launchers, acoustic scaring devices, and aerosol sprayers. Control and activation of the system were achieved using specialized software, a computer, and marine radar. The computer and radar were critical to the success of the system because they enabled the setup to activate the hazing devices only when birds flew within the protected airspace and to turn on only those devices near the intruders. The aerosol-applied chemical repellant reinforced the visual and audio scaring devices.

Over the course of a year, this demand-performance integrated system was 85-percent effective in reducing flyovers by waterfowl at two desulfurization ponds and 92 percent effective in reducing landings relative to the control pond. Moreover, the 24-h protection afforded by this system was 60 percent better at detecting birds than were ground observers and resulted in an annual savings of 4,000 hours of labor for the power company over labor expended on normal hazing operations. It may be possible to adapt this system to protect catfish ponds from depredating birds.

MAMMAL RESEARCH PROJECTS

Title: Control of Rodent Damage to Hawaiian Agricultural Crops

Goal: Develop safer and more effective methods for reducing rat damage to Hawaiian agricultural crops.

Controlling Roof Rat Populations in Macadamia Orchards—To design more effective control methods for roof rat populations in Hawaiian macadamia orchards, scientists must better understand the foraging behavior of this pest. Past and present research by staff of the NWRC Hawaii field station has been directed toward this goal. Past research efforts have identified key aspects of roof rat foraging behavior in macadamia orchards. Radio-tracking studies have determined that roof rats forage nocturnally in macadamia trees and spend little time, if any, foraging on the ground. A subsequent study using nontoxic bait treated with a biomarker showed that a significantly higher proportion of roof rats in macadamia orchards feed on bait placed in trees compared with bait placed on the ground or in burrows.

Macadamia growers in Hawaii currently try to control troublesome rat populations in their orchards by broadcasting rodenticides on the orchard floor. This use pattern does not appear to be appropriate in light of recent data on roof-rat foraging behavior.

Working with other NWRC scientists, Hawaii Department of Agriculture specialists and commercial manufacturers, the staff from NWRC's Hawaii field station helped to obtain a State registration for the use of the anticoagulant rodenticide diphacinone for use in bait boxes secured in macadamia trees. This registration may provide macadamia producers with a precise technique to control roof rat damage right where it occurs. Additional studies will be required to determine the economic thresholds for practical use of this rodent damage-control technique by producers.

Development of More Cost-Effective Methods To Control Rats in Hawaiian Native Habitats—Scientists at NWRC's Hawaii field station are assisting other Federal and State agencies, conservation organizations, and private landowners in Hawaii in efforts to control rats in native forest habitats. A graduate student at the University of Hawaii, working with staff at NWRC's Hawaii field station, completed research for her master of science thesis in 1997 by examining rodenticide bait requirements for broadcast applications of an anticoagulant rodenticide in Hawaiian native forests.

Both the Polynesian rat, introduced to the islands in association with early Polynesians, and the roof rat, introduced later by ship traffic, cause extensive damage to agricultural crops—particularly sugarcane and macadamia nuts. These rodents have also contributed significantly to the precipitous declines in endemic Hawaiian flora and fauna, preying on birds, eggs, native plants, and invertebrates and competing with native species for food and habitat.

The rodenticide diphacinone is already available for agricultural and conservation applications in bait stations, but its cost and the labor-intensive nature of the use of bait stations limit the effectiveness of the technique in the rugged, isolated parts of Hawaii that remain in native forest habitat.

Because aerial application of weatherproof bait pellets might overcome these limitations, NWRC personnel designed laboratory trials to determine minimum realistic dose rates and exposure times. Commercial 2.5-g pellets (containing 0.005 percent diphacinone active ingredient) were provided to both rodent species at varying rates. Six days of exposure and 30.0 g (12 pellets/rat) caused 90-percent mortality for Polynesian rats.

In actual field use, bait consumption and mortality rates would be expected to increase because rats continue to consume bait after ingesting a lethal dose. For field effectiveness, it will be important to develop application systems and baiting rates that allow all rats in an area to consume the rodenticide.

The long history of safe use of diphacinone in a variety of environments and the considerable existing data on its human health and ecological effects may make its use in native habitats an important tool for preserving Hawaii's native plants and animals.

Title: Integrated Pest Management Strategies for Wildlife Damage to Agriculture

Goal: Develop, test, and evaluate innovative and integrated methods and models to reduce wildlife damage to agricultural crops and property.

Repellent and Nutrition Research With Captive Porcupines—Porcupines cause significant localized damage to reforestation, agriculture, and structures in the Western United States. Currently, there is a heavy reliance on lethal methods to reduce porcupine numbers and subsequent damage. There is a need to develop effective nonlethal methods, such as repellants, to reduce potential hazards to protected and nontarget species. Unfortunately, little is known about the foraging ecology, nutritional requirements, and digestive abilities of these secretive, mostly nocturnal rodents.

NWRC scientists and faculty and graduate students of Washington State University have conducted a series of studies with captive porcupines. In nutrition trials, porcupines maintained their weight on diets of apple, acorns, or alfalfa, all of which are highly digestible. On a diet of willow leaves, however, porcupines did not maintain their weight. Although willow leaves have relatively high levels of some nutrients (such as nitrogen, crude protein, and energy), they also have the highest fiber content of tested materials, reducing digestibility.

In tests of potential repellants in pen trials, some materials (predator urines, semiochemicals, capsaicin, paradichlorobenzene, and 21-percent Thiram®) protected pine branches from foraging porcupines, whereas other materials (such as denatonium benzoate, denatonium saccharide, garlic oil, and 7-percent Thiram) did not repel porcupines. Semiochemicals (compounds isolated from predator anal glands) deterred porcupine feeding not only on treated pine branches but also on untreated branches nearby. Field trials will be conducted to assess efficacy and duration of protection under natural conditions.

Potential Repellants To Deter Black Bear Damage to Trees—Upon emergence from hibernation in spring, black bears damage young, fast-growing forest trees in many parts of the Pacific Northwest. The bears are seeking the sweet, nutritious cambium under the tree's bark. Damage to western larch, a highly prized commercial conifer species, in northern Idaho and western Montana can be locally severe. Forest and wildlife managers have relied on spring bear hunts to reduce bear populations and, hence, the potential for subsequent tree damage.

NWRC scientists are now investigating nonlethal approaches to reduce bear damage to trees. Potential repellants were applied to western larch trees about 15 m tall in commercially thinned

stands on State land in northern Idaho in early spring. The materials tested were denatonium benzoate (a very bitter compound), capsaicin (a very hot compound), and a water-based slurry of grizzly bear feces. The slurry was used because black bears are very fearful of grizzly bears and presumably of their odors. All three repellants were equally effective in these preliminary trials.

Investigators returned in late summer and found that 20 percent of the untreated (control) trees had been damaged by bears, whereas only about 10 percent of trees treated with one of three potential repellants were damaged. It appears that repellants can be used to reduce bear damage to conifer trees, but additional trials are needed to confirm these findings. It also will be important to find an efficient, cost-effective method of using repellants over large areas and in inclement weather situations.

Integrated Pest Management of Pocket Gophers—Pocket gophers are small burrowing rodents native to much of North America. Gophers cause damage by feeding on crops and young trees, chewing on buried cables, burrowing into dikes and levies, and producing large earthen mounds that damage field machinery. Control of gopher damage has relied on the placement of toxic baits or kill traps in burrows, but these methods are becoming increasingly expensive. In many areas, toxicants and traps have been restricted or forbidden outright.

NWRC scientists have conducted many studies to find ways to reduce gopher damage, including chemical, physical, and cultural methods. Additionally, Center scientists are investigating integrated pest management (IPM) strategies to reduce gopher damage. An IPM approach is especially important given the reproductive capabilities and rapid reinvasion rates of gophers into good habitat. Three components are necessary to implement an IPM strategy to reduce gopher damage: the ability to assess the potential risk for damage, techniques for monitoring gopher populations and assessing efficacy of control methods, and damage-control strategies and methods.

Gopher populations respond to many natural and human-induced habitat factors: soil type, elevation, slope, plant association, type of crop, and land-use practices, such as irrigation, fertilization, and herbicide application. Reduction of gopher damage should involve the manipulation of habitats and land-use practices to make sites less supportive of high gopher population densities. If an area has a history of gopher damage or high densities can be expected, the gopher population should be monitored closely. The feasibility, effectiveness, and legality of all possible damage-reduction methods, materials, and strategies should be evaluated. Often, more than one method should be employed to reduce damage or the potential for damage effectively. Crop growers and forest managers can benefit from the use of IPM strategies to reduce damage by gophers.

Title: Development and Evaluation of New Techniques for Resolving Predator Depredation Problems

Goal: Develop new or improved control technology systems for operational use in predator management.

Effectiveness of an Electronic Dog-Training Collar for Deterring Coyote Attacks on Domestic Sheep—New and improved methods are needed to deter predators from killing livestock. NWRC and CSU scientists tested the effectiveness of an electronic dog-training collar for deterring captive coyotes from killing domestic lambs by shocking coyotes whenever they attempted to attack lambs during a 22-week period. The electronic collar averted all 13 attempted attacks on lambs by 5 coyotes, greatly reduced the probability of attempted attacks, and caused coyotes to avoid and retreat from lambs for more than 4 months. This approach to aversive conditioning has potential for reducing coyote predation on domestic sheep in limited areas and may be applicable to a variety of other problems involving carnivore predation on domestic or endangered species.

Title: Management of Livestock Depredation: Developing More Selective Control Strategies

Goal: Develop effective and environmentally responsible strategies for reducing livestock depredation through selective targeting of predators.

Coyote Research in North-Coastal California: Identifying Sheep Killers—Coyote depredation of sheep has been studied during the past five and a half years at the University of California's (UC) Hopland Research and Extension Center. A succession of 4 graduate students from UC–Berkeley together with 23 field assistants conducted the research. An underlying objective was to learn more about those coyotes that kill sheep. The researchers assumed that if sheep-killing coyotes could be characterized, then control methods appropriate to the behavior of these animals could be developed.

In total, 65 coyotes were captured and radio-collared, and their space-use patterns were determined at over 18,000 tracking locations. During this time, 371 sheep confirmed to have been killed by coyotes, and 57 coyotes were removed in control efforts by trappers and Hopland personnel. In addition, field station records on predation losses attributed to coyotes and on coyote removals were analyzed for the 13-year period preceding the study. This represents the most intensive study to date of the space use and movements of coyotes on a large sheep ranch with annual coyote control.

Several lines of evidence support the conclusions that relatively few coyotes in the local population kill sheep and that these coyotes are primarily alpha pairs whose territories overlap pastures with sheep—particularly those with lambs. First, analysis of station records showed a trend of negative correlation between numbers of coyotes removed and subsequent depredation losses, suggesting that not all coyotes killed sheep and that control was inconsistent at removing those that did. Second, sheep kills were clustered in time and space. Third, radio tracking showed that coyotes used contiguous territories in the presence of sheep such that coyotes whose territories did not overlap pastures with sheep did not have access to them. In addition, coyotes located close to sheep kills near the estimated time of death have been alpha males. Fourth, nonselective removal of coyotes during the 1995 and 1996 lambing seasons did not stop depredation until removal of one or both of the alpha males in whose territory the kills occurred. Finally, a strategy of selective removal was used during the 1997 and 1998 lambing seasons. Removal was done primarily with the Livestock Protection Collar and involved only one to three coyotes per year. This removal effectively stopped depredation.

Title: Ecology of Coyote Depredation

Goal: Determine interrelationships between depredation on livestock and the abundance and behavior of predators and natural prey.

Decline of the Swift Fox in North America—The swift fox historically ranged from northern Texas to southern Canada. The range and abundance of this small burrowing predator underwent a widespread reduction in the 19th and early 20th centuries, mainly in response to human activities. This decline continues, and there is speculation that a major factor is competition with and by coyotes. Coyotes sometimes kill foxes and actively discourage them from using carcasses. Efforts to reintroduce the swift fox in Canada have been severely hampered by high fox mortalities, 50–60 percent of which are caused by coyotes.

Determining resource overlap between swift foxes and coyotes is essential to fox recovery efforts. NWRC biologists are studying overlap on the Piñon Canyon Maneuver Site in southern Colorado. Field work began in January 1997. To date, 180 foxes have been captured, and 73 have been radio collared: 34 males and 39 females. More than 10,000 telemetry locations have been made, and 1,000 den sites have been identified during the past 20 months.

At present, biologists are following 42 foxes and 17 coyotes. During 1997, eight dead foxes were documented; three of these were killed by coyotes. Another fox was killed by a badger, and one drowned in a stock tank constructed from a tractor tire. During 1998, coyote predation is suspected in 10 of the 15 fox deaths that have been documented.

NWRC biologists are also monitoring fox den sites to collect information about litter size and mortality before dispersal. In 1997, 12 of 18 social groups raised kits, but in 1998, only 14 of 25 groups produced offspring. Before the fall dispersal in August 1997, biologists collared 10 young of the year. Four of these animals died before reaching 1 year of age, and two more disappeared. The approximate reproductive chronology of swift foxes is December 15–April 14 for breeding and gestation, April 15–August 14 for pup rearing, and August 15–December 14 for dispersal.

Title: Reproductive Intervention Strategies for Managing Coyote Predation

Goal: Determine whether sheep losses to predation can be reduced by sterilizing coyotes on territories where sheep and other livestock are pastured. Determine if sterilization is a viable method of reducing coyote densities. Develop and transfer information critical to the registration and/or practical application of sterilant technologies and pharmaceutical products.

Immunization with Porcine Zona Pellucida To Cause Complete Infertility in Coyotes—NWRC scientists in Fort Collins, CO, and Logan, UT, have used immunization with porcine zona pellucida (PZP) to cause complete infertility in coyotes. Zona pellucida is a glycoprotein surrounding eggs in the female reproductive tract of mammals. Because the zona pellucida is similar in all species, researchers can use glycoprotein from swine to develop a vaccine for use in coyotes. In one study at NWRC, female coyotes were vaccinated in December 1997 and received two booster vaccinations in January 1998. No coyote that received the PZP vaccine had a litter, whereas all females receiving a placebo vaccine showed normal reproductive success. Otherwise, the breeding and territorial behaviors of treated and control coyotes were indistinguishable.

Over the next several years, NWRC biologists will attempt to isolate the portion of the PZP molecule responsible for contraceptive effects. This information is critical to the development of an orally deliverable, consistently effective, species-specific vaccine. Experiments also will attempt to identify a practical technology for the oral delivery of vaccine.

Title: Sensory and Behavioral Methods for Managing Predation on Livestock

Goal: Identify chemical repellants and deterrant methods and create attractive baits for target-specific delivery of pharmaceutical substances to reduce livestock depredation.

Visual Information for Prey Detection by Coyotes— Although chemical and auditory cues are important, coyotes typically rely on visual information for prey detection. Such cues are relatively immune to interference from wind, rain, and ambient temperature and can provide reliable information about prey type and location over relatively long distances. Despite their importance to foraging coyotes, the practical impact of visual cues as components of lures and attractants remains poorly understood. This lack of formal investigation is surprising because visual stimuli (e.g., plastic strips, bones, feathers) are sometimes used to orient coyotes in relation to traps, snares, and other devices.

NWRC scientists have shown that color can affect the distance at which wooden dowels are detected by captive coyotes as well as the likelihood that coyotes will approach dowels and pull them from the ground. Colors that stand out from the background are more attractive than colors that blend in. These findings have practical implications. For instance, colors might be used to increase the detection and activation of sodium cyanide ejectors (M–44's) by free-ranging coyotes. Although these devices are typically used to deliver a toxicant, they also represent an ideal mechanism for the delivery of vaccines and other pharmaceutical substances.

Research on this subject began in March 1997 at three study locations in Box Elder County, UT, and one location in Huron County, OH. Twenty M–44's were positioned at each location, and each was placed at the center of a 1-m circle that had been raked clear of debris. M–44 sites were randomly selected at 40 m perpendicular to an access road and 0.75 km or more apart. No M–44 was armed, no chemical lures were used, and 10 units were fitted with a black rubber top prepared from a 2-cm section of soaker hose. The remaining 10 units were fitted with white rubber tops. All sites were visited at 2-day intervals to record the number of tripped M–44's, and to identify any tracks near M–44's. Data were categorized according to M–44 color (black, white) and background (snow, no snow). Pulls were most frequent for white M–44's against a no-snow background, and were next most frequent for black M–44's regardless of background. White M–44's against a snow background were not pulled.

At all study locations, M-44's were activated by species other than coyotes. In Utah, mule deer tripped devices. In Ohio, M–44's were pulled by raccoons, white-tailed deer, and striped skunks. The apparent lack of species specificity was unexpected and should be investigated further. Findings are consistent with the notion that color can be used to improve the detection and activation of M–44's.

Title: Analysis of Taste and Olfaction in Selected Wildlife Species

Goal: Apply the methodology and findings from basic multidisciplinary chemosensory research to the development of new methods for controlling wildlife damage.

In Vitro Assays for the Identification of New Nonlethal Repellants—NWRC scientists and specialists at the Monell Chemical Senses Center in Philadelphia, PA, have developed in vitro assays for the identification of new nonlethal repellants. Effective repellants tend to be irritants that stimulate trigeminal neurons. For in vitro assays, trigeminal neurons were collected from one or two animals and then cultured in the laboratory. The responsiveness of these neurons to candidate compounds is measured using digital fluorescent imaging. To date, neurons from rats, guinea pigs, chickens, coyotes, white-tailed deer, Canada geese, and mallard ducks have been studied.

Rat and coyote neurons; guinea pig and deer neurons; and chicken, goose, and duck neurons tend to show similar response patterns. This finding suggests that rat nociceptors (nerves for receiving and transmitting painful stimuli) may be used as models for coyote nociceptors, guinea pig for deer nociceptors, and chicken for goose and duck nociceptors. One practical implication of this new technology is that hundreds of candidate repellants can be screened in the time that it previously took to screen a few compounds behaviorally. Lab screening using neurons also requires fewer experimental animals. It may eventually be possible to identify specific characteristics of molecules that predict irritation, thereby permitting the rational design of new repellent products.

Title: Reducing Mammal Damage To Forest Resources

Goal: Provide feasible and effective methods for reducing wildlife damage to forest resources.

The Impact of Timber Management on the Phytochemicals Associated With Black Bear Damage—Black bears forage on Douglas-fir vascular tissue in the spring, and this behavior can be severely detrimental to the health and economic value of a timber stand. Foraging is selective in that not all stands are damaged, and within a stand one tree may be stripped while its neighbor is ignored or minimally sampled. NWRC scientists conducted a series of studies to assess whether bear selectivity is affected by chemical constituents within vascular tissue and whether these constituents are affected by silvicultural practices. Tree selection by black bears is at least in part related to the concentrations of sugars and terpenes present in vascular tissue. Bears foraging in environments that offer choices are likely to select trees that offer the highest sugar-to-terpene ratio. This research suggests that the sugar-to-terpene ratio of Douglas-fir vascular tissue can be reduced by cultivating trees at higher stand densities and by pruning live crown cover. Urea fertilization affects the ratio only during the initial couple of seasons after application.

Although sugar concentrations are affected by environmental factors, terpene concentrations can be increased through genetic selection. It appears possible to select trees containing greater concentrations of terpenes without affecting positive attributes such as productivity.

Relationships Among Beaver Density, Beaver Dams, and Damage to Forest Resources in the Pacific Northwest—Staff from the NWRC Olympia, WA, field station are conducting a study of the relationship between beaver density and the damage to timber resources at 16 sites in Oregon coastal forests. Cooperators include Oregon timber companies, private wildlife damage specialists, and Oregon WS personnel.

From November 1997 to March 1998, NWRC scientists measured beaver damage to conifers and hardwoods and tested potential beaver density indices. The same sites are being monitored from November 1997 to November 1998 to determine the time between beaver removal and the arrival of new beaver and the durability of dams after beaver removal. Beaver density was determined by removing all beaver from sites scheduled for beaver trapping to reduce damage problems. The number of dams, dens, slides, and food caches was recorded for each site. Most den sites (91 percent) were bank dens, and a few den sites (9 percent) had lodges built as an extension of a bank den. Only two sites had a food cache.

There was no relationship between beaver density and the density of dams, dens, or active beaver slides. However, sites with higher beaver densities did have greater amounts of timber damage. Average beaver damage in areas with high beaver density ranged from 40 percent of trees 0–10 m from the waterline to 11 percent of trees 30–40 m from the waterline. Average beaver damage in areas with low beaver density ranged from 18 percent of trees 0–10 m from the waterline to 2 percent of trees 30–40 m from the waterline.

The lack of relationship between beaver density and dam density indicates that a small number of beaver may be able to maintain a relatively large number of dams. Therefore, it may be possible to reduce the number of beaver in a colony and associated beaver damage without reducing the number of beaver dams and ponds. These ponds are perceived to provide important habitat for a variety of species, including the coho salmon, which is a candidate for listing as an endangered species in this section of Oregon. Data from this study will aid wildlife managers in developing plans that reduce beaver damage while preserving important fish and wildlife habitat.

PRODUCT DEVELOPMENT RESEARCH PROJECTS

Title: Evaluation of Rodent Control Chemicals

Goal: Develop safe, effective chemical methods to reduce rodent damage to agricultural crops and rangeland and to provide for public health and safety.

Zinc Phosphide in Norway Rat Acute Dry Laboratory Tests—In the laboratory, NWRC biologists evaluated a 1.0-percent zinc phosphide–oat groat grain bait for controlling domestic Norway rats. Sixty white rats, 20 control and 40 treated, were placed on a 3-day, two-choice feeding study. Control rats received two dishes (40 g each) of the Environmental Protection Agency (EPA), Office of Pesticide Programs (OPP) rat and mouse challenge diet while the treated rats received a 40-g dish of the 1.0-percent treated bait and a 40-g dish of the OPP rat and mouse challenge diet. After 24 hours' exposure to the bait, 34 treated rats (85 percent) died; at 48 h, 2 additional rats (5 percent) died. The four animals (10 percent) that survived were basically noneaters of the treated bait. No control rats died. On day 1, the 40 treated rats consumed an average of 0.80 g of zinc phosphide bait and 2.13 g of challenge diet.

Differences between consumption of the two bait types were not significant for females but were significant for males. The mean intake of zinc phosphide on day 1 for the 36 rats that died was 48.52 mg per kg of body weight. The mean total intake for the four rats that survived was 15.70 mg/kg and ranged from 1.57 to 34.62 mg/kg. The 90-percent mortality exceeds the minimum efficacy standard of 70 percent established by EPA for rodenticides. These data will be submitted as a partial fulfillment for the reregistration of California's 1.0-percent zinc phosphide label.

A second study, sponsored by the California Vertebrate Pest Control Research Advisory Council (CVPCRAC) through a cooperative agreement with the California Department of Food and Agriculture (CDFA), evaluated the efficacy of 2.0-percent zinc phosphide grain baits on Norway rats. EPA had informed CDFA that efficacy data on zinc phosphide for controlling Norway rats were required as a partial fulfillment for their reregistration of zinc phosphide commensal rodent label. The objective was to evaluate 2.0-percent bait acceptance and efficacy of zinc phosphide bait for controlling Norway rats. All 40 Norway rats tested on the 2.0-percent zinc phosphide grain bait died after day 1.

Efficacy of Bromethalin Against the California Ground Squirrel—CVPCRAC also funded a laboratory study at NWRC through a cooperative agreement with CDFA to determine the efficacy of pelleted bromethalin baits in controlling California ground squirrels. Bromethalin is registered in the United States at 0.01 percent for commensal rodent control, and the CVPCRAC wanted to expand the registration to include field and rangeland rodents. A series of laboratory tests was conducted to determine if bromethalin is effective and has potential to control California ground squirrels. The objective was to determine the minimum bromethalin concentration producing 100-percent mortality, but after the first test, the focus was modified to determine if the 0.01-percent concentration was capable of producing 70-percent or greater mortality.

For the first test, 29 ground squirrels were placed on a 3-day, no-choice feeding study with 0.01-, 0.03-, or 0.10-percent pelleted bromethalin bait, and each animal was given 10 g of bait daily. Three of nine ground squirrels (33 percent) offered the 0.01-percent baits died within 3 days. Mortality was 80 percent for animals offered 0.03-percent baits and 100 percent for animals offered 0.10-percent baits. The total bromethalin ingested by the animals averaged 3.39, 4.37, and 7.86 mg/kg respectively.

In a second test, 60 California ground squirrels were selected for a 3-day, no-choice feeding test that exposed them to untreated baits or baits containing 0.01-percent or 0.03-percent pelleted bromethalin. The quantity of bait given each animal was increased to 20 g daily.

Mortality in the 0.01-percent and 0.03-percent treatment groups was 25 and 65 percent respectively; no control animals died. The total bromethalin ingested by the animals averaged 3.84 and 4.16 mg/kg at the two dosage levels.

In the third test, bromethalin formulated on oat groats was used instead of pelleted baits. This test was a 3-day, no-choice feeding test with a control group of 12 animals and 3 other groups of 12 animals each on the following 3 concentrations: 0.01, 0.03, and 0.10 percent bromethalin. Each animal was given 20 g of bait daily. Mortality was 17 percent for animals offered the 0.01-percent bait, 25 percent for the 0.03-percent bait, and 75 percent for the 0.10-percent bait; no control animals died. The total bromethalin ingested by the animals averaged 4.42, 2.81, and 7.37 mg/kg, respectively.

These data suggest that the minimum concentration producing the maximum mortality is approximately 0.07 percent, and the maximum mortality is approached when California ground squirrels consume a mean of 6.72 mg/kg of bromethalin in a single feeding.

Title: Research and Development of New Repellent Technologies for Rodents

Goal: Develop new, effective, environmentally safe behavior–biological–chemical repellent methods for reducing rodent damage to agricultural crops–grasslands, above- and below-ground cables, water impoundments, and farm buildings.

Capsaicin-Laden Soil Deters Digging by Gophers—NWRC scientists are trying to develop novel gopher repellent products and technologies. One of these technologies used the injection of chemicals into soil, an approach developed by the termite-control industry to create barriers to subterranean termites along the foundations of dwellings. This technology is currently being evaluated with gophers as a means for deterring burrowing behavior.

Preliminary results have demonstrated feasibility for capsaicin oleoresin as a deterrent to gopher digging. In a comparison of 5-, 10-, and 15-percent concentrations of capsaicin in soil, gophers spent increased time grooming and decreased time contacting and digging in treated soil at the higher concentrations. However, these effects were variable among animals.

Reducing Pocket Gopher Damage to Cables—With their characteristic gnawing and digging behaviors, pocket gophers can cut wire and fiber optic cable installations. NWRC scientists are evaluating bitter-tasting and hot-flavored chemicals such as denatonium benzoate and capsaicin in different cable-coating configurations to optimize repellancy as the animals attempt to gnaw.

Research has indicated that chemical surface coatings on the outer sheath of cable samples are ineffective in producing sustained repellancy under most conditions. However, the addition of a second sheath containing the agent could greatly increase repellent effects by enhancing contact with the chemical as the gophers attempt to gnaw. Studies have indicated that between 0.5 and 1.0 cm^3 of this material across 10 cm^3 of cable are sufficient to repel northern pocket gophers reliably over 10-day exposure periods.

Title: New Solutions for Wildlife Problems Through Biotechnology: Immunocontraception of Wildlife Pest Species

Goal: Develop and field-test economical and effective immunocontraceptive vaccines to control populations of pest mammalian and avian species.

Field Applications of Contraception for Managing Overabundant Deer Herds—NWRC is in the second year of a cooperative project with Cornell University at the Seneca Army Depot in central New York to develop field applications of contraception for deer. During 1997, 33 white-tailed deer were vaccinated with a gonadotropin-releasing hormone (GnRH) immunocontraceptive vaccine. These 33 deer produced 4 fawns total, or 0.12 fawn/doe, as compared with 1 fawn/doe in the control group. During 1998, in addition to the 33 GnRH deer, 25 deer vaccinated with PZP were added to the study. NWRC scientists are also testing single-dose GnRH vaccines using Freund's adjuvant and a new water-soluble adjuvant. Such single-dose vaccines will make immunocontraception a more practical tool for wildlife management. All deer were vaccinated using a dart gun. Fawning counts indicate that contraceptive vaccines have been very effective.

Avian Contraception—NWRC scientists, in cooperation with a CSU graduate student, tested three avian contraceptives using coturnix quail as a test species. Two compounds were immunocontraceptives targeting AGnRH (avian gonadotropin-releasing hormone) and cRCP (riboflavin carrier protein).

The immunocontraceptive vaccines gave poor results overall but did effectively contracept a few birds. Researchers believe that the failure of the vaccines to produce consistent results is due to an improper vaccination protocol. The other contraceptive is a cholesterol mimic, DiazaCon®. DiazaCon produced good results, shutting down egg production almost completely in females and producing infertility in males. Because it can be delivered via ingestion, DiazaCon has immediate potential for use in the field.

Title: Development of Analytical Chemical Methodology for Wildlife Research

Goal: Develop and apply new analytial chemistry techniques and approaches to wildlife research problems.

***3*-Chloro-*p*-toluidine Hydrochloride (CPTH) Residue Methodology**—NWRC chemists completed methodology to quantify CPTH residues in avian tissue accurately. Previous methods suffered from extremely variable recoveries. For the new method, deuterated CPTH (CPTH–d6) was synthesized and used as a surrogate for CPTH. Owing to a difference in molecular weight of 6 atomic mass units, CPTH and CPTH–d6 can be differentiated by mass spectrometry. However, because of the extreme similarity of their chemical structures, recoveries for both compounds were virtually identical over a broad range of fortification levels. Recoveries of CPTH–d6 fortified into real field samples can be used to convert observed concentrations of CPTH residues into actual concentrations of incurred residues. This approach is critical for the accurate estimation of secondary hazards associated with the potential secondary consumption of target birds following CPTH operations.

Pesticide Residues in California Range Grass—CVPCRAC funded NWRC research to develop a solid-phase extraction methodology to quantify chlorophacinone and diphacinone residues in California range grass. These analytical methods will be used by NWRC and other labs to support field studies required for the registration of chlorophacinone and diphacinone to mitigate rangeland rodent damage.

Sapwood Testing Methods—NWRC researchers developed analytical methodology and used it to quantify terpenes and carbohydrates in sapwood collected from commercial Douglas-fir stands. Studies conducted by Center biologists and chemists have shown that bear damage to trees is more likely when sapwood carbohydrate content is high, terpene content is low, or both. Analysis of sapwood samples from trees subjected to a variety of standard silvicultural practices suggests that carbohydrate content increases after fertilization or thinning and decreases after pruning. These data offer the timber industry nonlethal approaches to reduce losses resulting from bear damage.

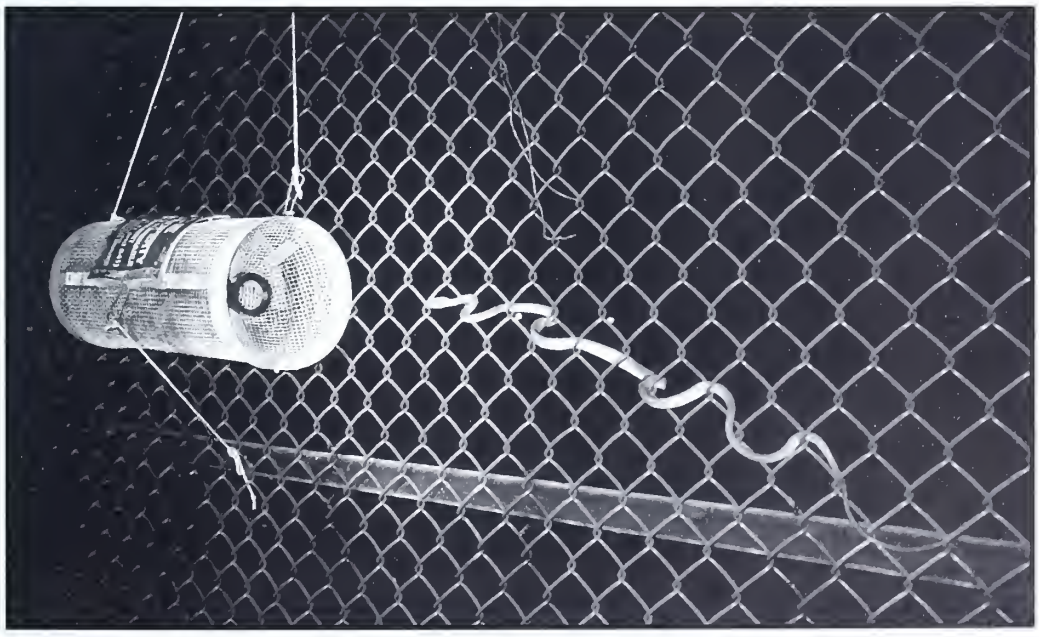
Title: Development of Control Methods for the Control of the Brown Tree Snake

Goal: Develop techniques to help control brown tree snakes on Guam and prevent their dispersal from that island.

Background—NWRC research into development of chemical methods for managing the brown tree snake (BTS) began in 1995 under Department of Defense (DoD) legacy funding. Fiscal year (FY) 1998 was the last year of the original project. The goal of this project was to develop chemical control methods (fumigants, toxicants, attractants, and repellants) that can be used in an integrated program to control and prevent the dispersal of the BTS from Guam and to reduce or help control snake populations in various island situations. NWRC has achieved considerable success in meeting these goals in a relatively short time for a species about which almost no such data were available in 1995.

Development of Toxicants and Toxicant Delivery Devices—Previous work identified several oral and dermal pesticides as being toxic to the BTS. Also, previous work with live traps showed that a dead mouse was effective for attracting snakes and that wire-mesh live traps had potential use in delivering toxicants. Because large-scale use of devices similar to live traps would be expensive, the goal of the FY 1998 research was to identify effective, less expensive devices. Three potential toxicant delivery devices with a dead mouse lure were evaluated: a commercial wire-mesh trap with one entry, a two-piece wire-mesh snake trap, and plastic pipe. The two-piece snake trap and plastic pipe were tested with one and two entries. The devices were randomly placed along transect lines for 4 consecutive days in several types of habitat. The mean overall visitation rate for the wire-mesh snake trap and plastic devices ranged from 10 to 13 percent and 13 to 16 percent, respectively. These results indicated that plastic pipe devices were equivalent to wire-mesh devices; plastic pipe devices are also less expensive. Additionally, the maximum effectiveness of the dead mouse lure was on days 2 and 3, probably reflecting its rapid rate of decomposition on Guam.

A concern about the use of toxicants is the potential for nontarget exposure. To address this nontarget issue, 20 camera surveillance detection systems were used under field conditions on Guam to monitor animals visiting one of the previously mentioned potential toxicant delivery devices. A dead mouse was placed inside the delivery device, and the surveillance systems recorded animal visits to it when placed along transects in forest and fenceline habitats for 24 h a day. The total exposure-nights for these 20 devices in the forest and fenceline habitats were 210 and 119, respectively. Animals recorded in the forest included 58 snakes and 2 animals tentatively identified as crabs. Animals recorded along fencelines included 8 snakes, 3 geckos, and 1 animal tentatively identified as a rat. This low level of nontarget activity suggests that judicious use of snake toxicants would not have a major impact on nontarget animals.



Development of an Inanimate Lure and Attractants—The goal of this research is to identify inanimate attractants, and substantial progress has been made in this effort. Previous research indicated that the odor of dead mice was sufficient to lure the BTS into traps but the odor of live mice alone, was not sufficent. A simultaneous visual cue had to be present to be effective. In FY 1998, decomposition odors were identified, and an artificial carrion odor was formulated to examine the carrion odor attraction phenomenon more thoroughly. However, owing to formulation and delivery problems, this formulation was ineffective (relative to live mice) for capturing brown tree snakes. Research is under way to develop emitter tubes that will more efficiently deliver appropriate concentrations of the components of the dead mouse odor as a chemical attractant.

Other field research on carrion odors showed seasonal variation in their attractiveness to the BTS. During the dry season on Guam, odor-only carrion lures were not as effective as they were during the wet season. Because one aim of the research was not to fail in attracting nearby snakes, the research approach was altered to include complex visual stimuli in the carrion odor delivery system. It is likely that a careful combination of stimuli may allow the development of a lure that is even more effective than the live mice currently being used. The Center currently is evaluating a lure device that combines movement and odor into a "super-normal stimulus suite." Initial testing of the device has shown that the multisensory approach is effective in attracting snakes.

Identification of Snake Repellants—Center scientists are attempting to identify compounds that can be used to drive snakes from enclosed spaces. The FY 1998 experiments focused on five active natural product ingredients as snake repellants. These products were selected from the extensive list of ingredients and natural products tested in FY 1997 based on their likelihood of meeting human health and safety concerns as well as their likelihood of requiring the least amount of support data for registration by EPA under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA).

Tests were conducted initially on the efficacy of thermal fogs on snakes contained in simulated cargo. Unfortunately, this delivery mode destroyed the activity of the repellant. Tests are now concentrating on delivery systems in the form of cold-generated fogs and vapor-buoyant forms of the repellant. These delivery forms are desirable because they have greater penetrating power for complexly configured crevices and, hence, should have an increased likelihood of reaching the snakes. Because of their particle sizes, aerosols work well but tend to be restricted in use to direct line of sight. A convenient, portable repellent-delivery device would be useful in many situations, including assisting WS canine units in flushing snakes from cargo, equipment, airplanes, and other locations after dogs have given an indication that snakes are present.

Analytical Chemistry Methodology and Validation—During FY 1998, NWRC chemistry personnel at Fort Collins developed and validated analytical chemistry methodology for the quantification of the candidate toxicant rotenone in brown tree snakes. The method limit of detection for rotenone in whole-body brown tree snakes was 0.017 mg per kg of body weight. Rotenone recoveries from snakes fortified with rotenone at 0.035, 4.82, and 250 mg/kg were 99.2, 87.8, and 85.6 percent, respectively. This is the third potential toxicant for which such previously unavailable methodology has been developed.

This methodology was then used to determine rotenone residues in snakes that were dosed orally or dermally with rotenone on Guam. For snakes dosed dermally with rotenone at 2.5–80 mg/snake, whole-body residues ranged from 2–31 mg/kg. The mean residue in fatally dosed snakes was 11.4 mg/kg. The mean residue in surviving snakes was 0.84 mg/kg. The lowest dermal dose of rotenone that killed all snakes was 10 mg/snake. The mean whole-body rotenone residue for these snakes was 5 mg/kg.

In an experiment to help determine dermal toxicity, snakes crawled through a soybean oil solution containing rotenone at 0.5 percent by volume. Whole-body residues ranged from 0.1 to 2.3 mg/kg. Mean residues in fatally dosed and surviving snakes were 2.0 and 0.09 mg/kg, respectively.

For snakes dosed orally with 10 mg rotenone in a quail chick, rotenone residues were extremely variable, and ranged from 0.68 to 61 mg/kg. Mean rotenone residues were 30 mg/kg. All snakes in this 10-mg-treated group survived. The implications of these data are that the toxicity to snakes of chemicals in a bait is different than when applied by gavage. That is, the carrier affects the toxicity of the chemical. Future research will be directed at improving toxicant delivery, possibly through encapsulation.

Improving Effectiveness of Dog Team Searches and Operational Trapping—NWRC dog team and trap evaluation research is conducted with funds provided to WS' Washington State office and obtained from the DoD under its "Operational Control of Brown Tree Snakes in Guam Program."

BTS populations are controlled on Guam by WS personnel at civilian and military air- and seaport facilities and other cargo staging areas to curtail the snake's potential dispersal to other vulnerable locations. Three primary control methods are employed: trapping, detector-dog searches of cargo, and nighttime capture during spotlight searches of fencelines. NWRC has been investigating the efficacy of these control activities, and data have been collected and analyzed from the initial phases of the research.

Previous findings have indicated that trapping on plot perimeters is an efficient strategy that effectively removes brown tree snakes from such plots even in fragmented habitats. Trapping can virtually remove snake populations, and reinvasion is slow. Recent research investigated larger plot sizes for which perimeter trapping might be effective. A 17.1-ha plot was set with traps on its perimeter only for 22 weeks. Captures declined to very low levels after only 6 weeks. After the 22 weeks had passed, traps were positioned inside and around the edges of the plot for an additional 8 weeks. Only 5 snakes were captured in the interior. Perimeter trapping now appears to be effective for plots more than twice as big as those for which this strategy had previously been demonstrated effective (8 ha). This information is important to maximizing resources related to trapping efforts.

Research to quantify the effectiveness of dog-team inspections continued in FY 1998. In one study, snakes in escape-proof containers were placed in cargo without the knowledge of the handlers. When inspections were conducted using standard operating search patterns, most, but not all, planted snakes were discovered. These research efforts are directed at compiling a sufficiently large data base using trials with planted snakes to answer questions about inspection circumstances that increase or decrease the probability of finding a hitchhiking snake. Also, the reasons that snakes might be missed during inspections are being examined with the intent of minimizing the risk of this occurring.

PROGRAM SUPPORT

APHIS Registration and Reregistration Status

Pesticides, Drugs, and Vaccines for Wildlife Services— The WS program manages wildlife–human conflicts by using an integrated approach involving habitat manipulation, harassment, removal, repellants and/or vertebrate pesticides. Some of the chemical products employed in vertebrate control operations are used in such small volumes that private industry cannot afford to develop, register, and produce them profitably. APHIS has assumed the responsibility for maintaining registrations for some of these minor-use vertebrate pesticides, drugs, and vaccines, thereby ensuring that WS program managers will continue to have these necessary tools. The product development research program at NWRC is responsible for meeting the data requirements imposed by EPA for maintaining these products. Product development personnel regularly meet with EPA and Food and Drug Administration (FDA) personnel to address registration issues for WS pesticides, drugs, and vaccines.

Vertebrate pesticides registered with EPA and maintained by APHIS include 7 active ingredients required in 25 to 30 individual end-use products and 1 Experimental Use Permit. The active ingredients in the APHIS-maintained vertebrate pesticide products include Compound 1080, used only in the Livestock Protection Collar; sodium cyanide, used only in the M–44 for controlling problem canines and foxes; sodium nitrate and carbon, used in the gas cartridge for controlling rodents, coyotes and foxes; DRC–1339 concentrates (Starlicide™) used for controlling starlings, blackbirds, gulls, crows, ravens and pigeons; strychnine alkaloid for belowground pocket gopher control; and zinc phosphide baits and concentrates for rodent control.

APHIS has 2 vertebrate drugs registered with FDA for use by WS personnel. Alpha-chloralose is an orally delivered tranquilizer for removal or relocation of urban waterfowl and pigeons. Propiopromazine hydrochloride, another orally delivered tranquilizer, is used in a tranquilizer trap device to sedate animals caught in leghold traps or snares. FDA has also issued Investigative New Animal Drug authorizations to APHIS for two vaccines, GnRH and PZP, for use as immunocontraceptives in deer and other mammals. Refinement of the vaccines and delivery systems is continuing, and tests are planned for other mammals. NWRC has initiated discussion with FDA concerning three potential avian contraceptives, and preliminary testing with waterfowl may occur in 1999.

Reregistration Status and Activities—The reauthorization of FIFRA in 1988 mandated reregistration of all older pesticides. All active ingredients registered by APHIS were subject to this requirement. NWRC efforts led to the successful reregistration of six active ingredients (carbon, sodium nitrate, sodium cyanide, Compound 1080, DRC–1339, and strychnine), and all but six data requirements for strychnine have been met. The six remaining studies for strychnine were completed by the end of 1998. A Reregistration Eligibility Decision was received in September 1998 for zinc phosphide, the only remaining APHIS-maintained vertebrate pesticide awaiting reregistration.

The Center's product development personnel coordinate 2 consortia to generate data required for reregistration of strychnine and zinc phosphide products held by private industry, State agencies, and APHIS. Additionally, NWRC coordinates a consortium for Starlicide products. These 3 consortia have the combined responsibility for more than 90 vertebrate pesticide registrations maintained by more than 30 registrants.

Registration Activities and New Pesticides and Uses— Registration unit personnel have been active in providing data and technical support to allow APHIS to make label changes to existing vertebrate pesticide uses. Of particular interest to the WS program is reducing the length of the fallow period required following the use of DRC–1339 for blackbird control in rice-growing areas. With the cooperation of stakeholder groups, NWRC investigators initiated a study in 1998 to evaluate plant uptake of radio-labeled DRC–1339. The results of this study will determine if changes can be made to plant-back period restrictions for DRC–1339 for many use sites associated with cropland.

At the request of WS personnel, label changes have been initiated to expand the use of bait materials and methodology with some DRC–1339 uses. Work continued in 1998 on the registration of Mesurol, a chemical aversive agent, in eggs for reducing the predation on threatened and endangered species at nesting locations. This registration is expected in time for the 1999 breeding season.

Data Submissions and Reports—NWRC is responsible for developing or obtaining all the data needed to meet APHIS and WS program and consortia commitments to EPA and FDA. The NWRC registration unit manages all data-gathering activities and coordinates these activities with the Data Support Team in APHIS' Policy and Program Development unit. During 1998, NWRC conducted, contracted, or prepared 16 data submissions for 6 vertebrate pesticides, 2 drugs, and 2 vaccines. In addition to the data submissions, NWRC also prepared 13 annual, semiannual, or quarterly reports concerning product use and countless product-related correspondence for EPA or FDA on behalf of WS, APHIS, or the consortia.

Pesticide and Drug Registration Files—Three pesticide and drug registration data bases were developed by registration unit personnel. The Pesticide Registration File data base provides information on the status of individual data requirements for all APHIS or consortia vertebrate pesticides. A second cross-referenced bibliographic data base, on ProCite™ software, contains all known citations of published and unpublished information on 22 pesticides and drugs of interest to the WS program. This data base is complete through the early 1990's and is in the process of being updated. Finally, NWRC personnel continue to develop a DRC number data base. This searchable data base contains DRC numbers, chemical names, and Chemical Abstracts Service registry numbers for 6,800 chemicals that were screened between 1960 and 1987 by NWRC for pesticidal properties. In addition, the data base indicates the type, quantity, and location of data developed by NWRC and provides access to summary or raw data for research purposes. The data referenced in the DRC number data base will reside in the NWRC archives and will be made available upon request.

Data Provided to State Regulatory Agencies and Cooperators—NWRC personnel continue to interact routinely with the California Department of Pesticide Regulation (CAL–EPA) to allow the use of APHIS pesticides to continue in that State. Other States are following in CAL–EPA's footsteps by requiring extensive data, which NWRC is providing on an as-requested basis. In addition, WS program personnel or cooperators often need access to, or summaries of, data produced by NWRC or others to include in environmental assessments, environmental impact statements, and in Section 7 consultations with the U.S. Fish and Wildlife Service. NWRC is the prime supplier of these data to the WS program and its cooperators, and often includes summaries and necessary interpretations. More than 100 significant requests were handled in FY 1998 by NWRC; most were partially or completely customized for the requester.

Tranquilizer Trap Device Handbook—Registration unit personnel assisted WS' Operational Support Staff in developing the "Tranquilizer Trap Device Handbook (Training, Use, and Restrictions)." Training based on the contents of this manual is required for WS personnel before using the device.

PROVIDING WILDLIFE SERVICES

Goal: Provide high-quality wildlife damage management services that result in the protection of agricultural, wildlife, and other natural resources, property, and human health and safety.

NATIONAL SUPPORT

Vultures—A biological technician from NWRC's Gainesville, FL, field station assisted WS operations in trapping and removing nuisance vultures in Leesburg, VA. The town of Leesburg, about 20 miles northwest of Washington, DC, has had up to 300 vultures roosting during the winter. The birds roost in only a few trees within the historic district, but their droppings and damage to the trees prompted the town to contract with WS to trap and remove the birds after local harassment efforts failed. Forty-three birds were trapped, tagged, and released along the western county line. The Florida field station has continued to evaluate the relocation of vultures as a management tool.

Experimental Aircraft Association Convention—Biologists from NWRC's Sandusky, OH, field station worked at the APHIS–WS information booth at the Experimental Aircraft Association Convention in Oshkosh, WI, July 28–August 3 to promote the awareness and reporting of bird strikes. This annual air show is the largest gathering of pilots in the world, attracting over 800,000 visitors. WS' displays of photos on aircraft damaged by bird strikes and promotional material on reporting bird strikes were well received and drew many questions. The national bird strike data base maintained by NWRC is critical for defining the extent and nature of the wildlife problems to ensure that research and management programs to reduce strikes can be properly focused, justified, and evaluated.

American White Pelican Banding Project—On June 27, 1998, NWRC biologists, with the assistance of WS personnel from Louisiana, Mississippi, North Dakota, and headquarters, banded immature American white pelicans in a nesting colony at Chase Lake, ND. WS and 30 volunteers from the Fish and Wildlife Service, the U.S. Geological Survey's Biological Resources Division, North Dakota State University, the North

Dakota State Game and Fish Department, and St. Cloud State University banded 2,600 pelicans. NWRC is studying pelican migration and movement patterns to provide better information to catfish producers experiencing pelican damage and to the USAF for its bird-strike data base.

Master Gardeners Training— NWRC provided training in wildlife damage management to volunteers through the CSU extension program in June 1998. Master gardeners were trained to provide advice to homeowners regarding urban pest problems and given experience in trapping pocket gophers.

Beaver Repellent Studies in the Southern United States— The 1996 WS Research Needs Assessment identified beaver damage problems as a critical research area. As a result, an NWRC scientist has worked with WS personnel in Mississippi to identify specific research objectives to increase and improve methods available to control beaver damage. Studies have been conducted to assess the efficacy of several potential chemical repellants (capsaicin, denatonium saccharide, Thiram, and synthetic fermented egg) to deter beavers.

Results to date indicate limited to no avoidance of these chemicals by beaver. However, preliminary trials indicate that beaver damage to trees can be reduced by painting their stems with textural repellants using mixtures of sand and alkyd paint. Uncoated stems or stems coated only with paint were severely damaged during a 2-week trial, but stems coated with the sand–paint mixture received only minor damage.

Future research is being planned to assess the potential of a toxicant bait, another textural repellant, and a tension trigger for traps that would reduce nontarget captures. NWRC is also collaborating with WS to assess the efficacy of an artificial floating lodge trap developed by WS field personnel.

Evaluation of Tranquilizer Trap Device for Delivering Propiopromazine Hydrochloride to Coyotes Captured in No. 3 Soft-Catch Leghold Traps—WS field personnel capture predators during operational control using leghold traps. The program is also called upon to trap and relocate endangered predators, such as wolves that are involved in livestock depredations. Trap humaneness and the inadvertent trapping of nontarget species are important issues both to the program and the public. To meet these concerns, the WS program requested development of a tranquilizer trap device. Modification of leghold traps by adding this device reduces foot damage, struggling, aggression, and escapes and eases the release of nontarget species, such as dogs. As a result of this research effort, a tranquilizer trap device with the immobilizing drug proprioprozamine is available from the Pocatello Supply Depot at $5.00 each. However, the high cost of this device has limited its use by WS personnel. Clearly, a more economical device is needed. NWRC and the Pocatello Supply Depot are conducting trials under simulated field conditions of a new device, the parts of which are commercially available. If effective, the savings would be significant to the program. If preliminary trials are successful, WS operations personnel will conduct field evaluations.

American Bird Conservancy Policy Council Meeting—A biologist from NWRC's Mississippi field station presented a talk and participated in a panel discussion of fish-eating birds at the September policy council meeting of the American Bird Conservancy, a nonprofit organization dedicated to the protection of wild birds and their habitats throughout the Americas. This group was formed in 1994 to coordinate collaborative approaches among bird conservation groups and to provide an accurate picture of avian conservation to the public.

A major focus of NWRC research at the Mississippi field station is the double-crested cormorant. Cormorants cause significant economic losses at southern aquaculture facilities, are a perceived threat to sport and commercial fisheries on northern lakes, cause major ecological destruction of their breeding habitat, and compete with other colonial water birds for nesting sites. An integrated management approach is needed to deal with the various issues surrounding cormorants in a comprehensive manner.

Buck Island Reef National Monument, U.S. Virgin Islands—Biologists from WS' Alabama State office and NWRC assessed the rat populations at Buck Island Reef National Monument, U.S. Virgin Islands, at the request of the National Park Service from February 16 to 21, 1998. The introduced rats are preying on eggs and hatchlings of endangered sea turtles and least terns.

WS staff confirmed the presence of a substantial rat population over the entire island and extensive damage to native vegetation. WS biologists also confirmed the continued presence of a mongoose population, based on tracks, despite a Park Service eradication effort in the 1980's. WS and Park Service biologists developed a plan for a rat and mongoose monitoring and management program with the eventual goal of eradicating of both species from Buck Island. Eradication would be essential before a proposed reintroduction of the endangered St. Croix ground lizard could proceed.

INTERNATIONAL COOPERATION

Bird–Aircraft Hazards in Mexico—An NWRC biologist made a second trip to Mexico City in January 1998 to assist the Government of Mexico and the National University of Mexico in evaluating bird hazards at proposed sites for a new international airport. These consultations have been sponsored by the Mexican Ministry of Communication and Transport through an agreement with the FAA. Bird species hazardous to aviation, such as waterfowl and vultures, are common in the Mexico City region, and the Government of Mexico wants to ensure that its new airport is designed to minimize attractiveness to birds. Biologists have censused bird populations during fall and winter in wetland, agricultural, and landfill areas throughout the Mexico City valley and made recommendations not only to minimize bird strike hazards at the proposed airport sites but also to develop and enhance important wetlands away from the proposed sites. Such advance planning is essential for developing environmentally sound and efficient bird-hazard reduction programs for airports. Bird strikes are of particular concern in Mexico City because of the high elevation (about 7,400 ft) of the existing and planned airport sites.

Agricultural Bird Problems in Uruguay and Argentina—An NWRC scientist from Fort Collins traveled to Uruguay and Argentina between March 23 and April 4, 1998, for the United Nation's Food and Agriculture Organization to assist both countries in finalizing a proposed project to address bird pests to agriculture. During this trip, a final technical report covering 15 external consultancies, a project document review, and 2 training courses were completed. The two governments are now determining how best to implement this important project: birds greatly affect agricultural production in both countries.

Foreign Agricultural Service Russian Research Grant—NWRC was awarded a competitive research grant from the USDA's Foreign Agricultural Service's Research and Scientific Exchange Division to fund a collaborative research study with Dr. Vera Voznessenskaya of the Russian Academy of Sciences. The study will evaluate the use of predator urine to control reproduction in rodents. Dr. Voznessenskaya visited NWRC in April 1998 to initiate this collaborative research effort.

Reducing the Leptospirosis Hazard in the Azores—At the request of the USDA's Foreign Agricultural Service and DoD, an NWRC scientist visited the Azores Islands in the North Atlantic to a ssess the relationship between introduced rodent populations and the occurrence of leptospirosis bacterial infections and deaths in humans. The disease is probably contracted from water contaminated by rodent urine and feces and possibly from infected pets and livestock. The islands of the Azores offer abundant food, water, and shelter for rodents because of the mild climate, abundant rainfall, lush vegetation, volcanic rock formations, and extensive dairy cattle industry.

The scientist toured the island of Terceira and met with Portuguese veterinarians and government representatives. He presented an overview of rat biology, ecology, and management. In addition, he recommended that (1) the rodent populations be studied and monitored, (2) the availability of certain foods used by rodents (garbage, pet, and livestock feed) be reduced, (3) an effective rodent population reduction program be designed and implemented, and (4) the exposure hazard for people in high-risk occupations (such as dairy farmers) be lessened by the use of rubber gloves and disinfectants in pet and livestock water containers.

Galapagos National Park, Ecuador, Workshop—An NWRC scientist participated in a planning workshop in the Galápagos National Park, Ecuador. The workshop focused on strategies for protecting critical habitats for giant tortoises on Isabela Island by removal of more than 100,000 feral goats whose population has grown drastically since introduction in 1979. Participants represented the Ecuador National Park Service, the Charles Darwin Foundation, Landcare Research (New Zealand), U.S. Fish and Wildlife Service, U.S. Geological Survey, APHIS, and several private consulting companies.

The group spent several days visiting habitat areas (primarily rough lava with thick scrub forest vegetation), evaluating the existing program and several proposals and developing a draft plan and cost estimates for future use by the Ecuador National Park Service. Partial funding for this effort has been obtained, and a program to remove the goats will be implemented in the near future.

Rodent Pests in Mexican Sugarcane—Dr. Beatriz Villa, from the Universidad Nacional Autónoma de Mexico in Mexico City, visited the NWRC facilities in Fort Collins on October 8, 1997, to confer with NWRC scientists on rodent damage assessment, research, and control methods. Dr. Villa conducts research in Mexico on several rodent pest species that damage a variety of agricultural crops. She also presented a seminar entitled "Rodent Pests in Mexican Sugarcane," which stressed the economic impact of damage and future plans for developing integrated control programs.

Dickcissel Damage in Venezuela—The dickcissel is a small grassland bird that breeds in the Central United States and winters in Venezuela. In Latin America, damage to rice and sorghum by wintering dickcissels has been compared with damage caused by quelea birds in Africa and red-winged blackbirds in the United States. In Venezuela, where virtually the entire dickcissel population spends the winter, some farmers resort to using organophosphate pesticides to kill roosting birds as a means of protecting their crops.

A single roost can contain up to 3 million dickcissels, possibly 30 percent of the entire species population, and thus spraying with toxic pesticide could have a major impact on the world's dickcissel population. Such mortality probably was responsible for drastic declines in dickcissel breeding populations in the United States during the 1960's and 1970's.

Reducing the risk to this species means alleviating the economic pressure of crop losses on Venezuelan farmers. In June 1998, an NWRC biologist participated by invitation in a workshop in Acarigua, Venezuela, to develop strategies to reduce this conflict. The workshop was attended by local government wildlife officials, Venezuelan conservationists, agricultural experiment station and university personnel, and rice and sorghum producer organizations. In addition to the NWRC representative, participation from the United States included the American Bird Conservancy, National Audubon Society, National Fish and Wildlife Foundation, and the Nature Conservancy.

An action plan was adopted that will address farmers' concerns in the short term and also provide for long-term management of wintering dickcissel populations. Implementation of the plan is contingent on obtaining cooperative financial support from participating organizations.

Swedish University of Agricultural Sciences—An NWRC scientist and a biologist at the Swedish University of Agricultural Sciences are collaborating on field evaluations of more than 20 sampling methods that can be used for assessing animal damage to crops. Their approach has been to use fully enumerated field populations in large computer simulations to evaluate plotless density estimation methods.

National Autonomous University of Mexico—NWRC continued collaborative consultation and research with investigators in Mexico City on studies of pocket gophers, which cause extensive agricultural losses in Mexico to sugarcane, grain crops, orchards, and forage on rangelands. Several manuscripts have been previously produced, and studies are continuing on a variety of topics concerning pocket gopher and other rodent damage problems in Mexico to several crops.

Dingo Assessments in Queensland, Australia—An NWRC scientist is collaborating with zoologists from the Department of Natural Resources in the Queensland, Australia. The focus of this research is on dingo predation of livestock with an initial emphasis on evaluating methods for indexing wild canid populations. A passive tracking station was developed and found to be the most sensitive to the presence of wild canids. The station also is sensitive for indexing other species present in the area that may have population responses to changes in dingo populations. Monitoring dingo populations is an important component in the management of livestock losses, and research results could generate parallel applications for coyotes in the United States.

UNITED STATES DEPARTMENT OF AGRICULTURE

VALUING AND INVESTING IN PEOPLE

Goal: Promote an organizational culture which values and invests in our people to support their professionalism, competency, and innovation as Federal leaders of wildlife damage management.

ExCEL Program—Geraldine McCann, a biological technician from NWRC, spent 2 weeks at the WS' Operational Support Staff headquarters in Riverdale, MD, in January 1998 to assist with assembling the annual WS highlights report. This detail was part of Ms. McCann's training in the APHIS ExCEL program. The goal of the program is to provide continual learning opportunities for selected individuals and to ensure that they gain or maintain the skills necessary to contribute effectively to the agency's mission and vision in times of change in the workplace. The new ExCEL program has been designed to be a flexible, competency-based training program offering a variety of training methodologies, both classroom and self-study, that can be tailored to the needs of the participants.

APHIS Leadership Today and Tomorrow Program Council—Richard Bruggers, Assistant Director at NWRC, was selected to be a member of the APHIS Leadership Today and Tomorrow Program (LTTP) Council to help guide this APHIS initiative in developing skills in prospective future managers. He also is serving as a mentor to a Plant Protection and Quarantine participant in the LTTP.

Deputy Administrator's Award—Richard Bruggers received the 1997 Wildlife Services Vision Award in recognition of strategic leadership of the NWRC. The award related to his leadership in conducting a WS Research Needs Assessment and developing and implementing the Project Management System within NWRC.

Graduate Degrees Awarded—Two NWRC chemists recently obtained graduate degrees while completing NWRC research aiding the needs of the WS program. Bruce Kimball completed his Ph.D. requirements and successfully defended his dissertation, "Chemical Ecology of Vascular Tissue Foraging by Black Bears," at CSU. His research provided the timber industry with a greater understanding of factors leading to black bear-induced timber losses as well as suggestions for modifying silvicultural practices as a nonlethal means of reducing damage. David Goldade completed his M.S. requirements and defended his thesis, "Solid Phase Extraction/Reversed Phase Liquid Chromatographic Method for the Quantitation of the Rodenticide Difethialone in Biological Matrices," at the University of Colorado. The chemistry methods developed during these research efforts will permit NWRC to conduct secondary hazard studies required for EPA registration and subsequent use of a new rodenticide for wildlife damage management. The research for both degrees was partially supported by stakeholder funding.

Jack H. Berryman Award—Retired NWRC employee Guy Connolly received the Jack H. Berryman Institute Award for Lifetime Career Contribution on March 3, 1998, at the 18th annual Vertebrate Pest Conference in Costa Mesa, CA. Connolly has had a distinguished research career with NWRC, working on a number of projects related to coyote depredation control, including

the Livestock Protection Collar and the M–44 device. In addition to his numerous publications on coyote biology and management, Connolly has also published more than 30 papers on mule deer and Columbian black-tailed deer.

WS Safety Awards—Ron Paciorek, a biological technician at the Starkville, MS, field station, received the FY 1997 WS Safety and Health Employee of the Year Award for his attention to safety and health matters, personal involvement in fitness and volunteer work, and for initiating and promoting appropriate safety training programs for the employees at his location.

NWRC's analytical chemistry unit was nominated for the FY 1997 Safety and Health Unit of the Year Award and received a Certificate of Appreciation. NWRC Denver and Fort Collins employees were nominated for an FY 1997 WS Special Achievement Award for the accident-free and safe commuting of 75 employees over 150,000 miles during a 3-year period and also received a certificate of appreciation.

UNITED STATES DEPARTMENT

INFORMATION AND COMMUNICATION

Goal: Collect and analyze internal and external information to monitor and enhance program effectiveness. Communicate internally and externally to accomplish our mission and to build an understanding of the Federal role in wildlife damage management.

INFORMATION SERVICES

NWRC Library—The NWRC library continued its commitment during 1998 to expand electronic access to publications and other research information. The NWRC Website was updated to enhance overall appearance and readability. Additions included new photos and text, the 1996 and 1997 NWRC highlights reports, annual publications lists for 1990–98, the NWRC brochure, and introductions to the various Center research programs with image map links to corresponding projects.

Library staff studied various options available for providing materials full-text on the Web and chose to implement use of Adobe's portable document format in order to make all 1998 Center publications available for downloading. An e-mail address was added to the home page to provide a direct contact point for our Web users, and the library began functioning as the referral point for all incoming e-mail.

Numerous publications needed distribution in 1998, and the library staff mailed out more than 400 copies of "Contraception in Wildlife Management" and 470 copies of the "Repellents in Wildlife Management Proceedings." In addition, 3,126 copies of the 1997 version of the present highlights report, the Center's Research Update newsletter, the new Center brochure, and the 1997 annual publications list were mailed.

To provide research and operations staff with needed information, Library staff requested more than 1,100 books and photocopies from other institutions and sent more than 360 items to outside requesters. More than 11,000 photocopies of inhouse library materials were made and distributed to various individuals and projects. Library personnel provided 265 literature searches on subjects such as corvid predation on shore birds, plant species with possible chemical repellent properties, deer and black bear damage, gull predation on salmon and trout, vulture control and ecology, and food habits of such species as the yellow bittern and the bullfrog. Library personnel also provided extensive citation searching on

rodent species to aid WS Operations staff in compiling information for the rodent damage control and environmental assessments.

A Windows™-based interface was purchased for the online catalog, as well as cataloging and serials software. To provide more immediate access to wildlife literature citations for WS end users, the library, on a trial basis, instituted limited Internet access to an online wildlife database. Response from users was overwhelmingly favorable, and NWRC will provide access to a larger number of users in FY 1999.

Archives—Current research documents and historic material continued to be processed and added to the NWRC archives. Various quality assurance (QA) studies, pilot studies, lab notebooks, and chemical methods were archived. More researchers from outside NWRC made use of the Center's archive services. In 1998, eight requests for a wide variety of materials from the miscellaneous research collections were processed. Previously archived NWRC Animal Care Committee records were inspected by APHIS' Animal Care Program in 1998, and QA research records were audited by EPA in April.

Information on Stored Food Protection Going on the Internet—The Food and Agriculture Organization of the United Nations is compiling "Postharvest Compendium," a comprehensive book on postharvest food information that will be available on the World Wide Web. This book will be useful in the design, organization, or implementation of postharvest programs, including technical assistance projects and applied research.

NWRC scientists produced a chapter for this electronic publication on the management of rodent, bird, and other vertebrate pests of farm-stored grains and legumes. The chapter presents an overview of reported losses by country and a brief account of the major pest species including rats, sparrows, pigeons, and crows. It also describes recognition of signs and damage of various species and basic approaches to reducing losses, including sanitation, prevention of pest access to foods, and population reduction strategies. Additional references and technical assistance sources are presented.

Postharvest food losses to vertebrates occur worldwide and can be especially severe in developing countries. As the world's human population continues to increase, the importance of stored food protection at the farm level can be expected to intensify.

SEMINARS

During FY 1998 NWRC continued to be a focal point for interesting seminars by its own and visiting scientists.

NWRC SEMINARS

Speaker	Affiliation	Title
Robert Mason and Michael Greene	Oregon State University	Research on Brown Tree Snake Reproduction
Steve Bagenski	APHIS, Plant Protection and Quarantine	Overview of Plant Protection and Quarantine Activities in Miami, FL
Mary Coussons–Reas	University of Colorado–Denver	Stress and Immunity: Bidirectional Relationships in Animals
Brian Petroff	Ohio State University	Regulation of Uterine and Ovarian Function by Prostaglandin F–2 alpha
Mark Drew	Texas A&M	Application of Assisted Reproduction Techniques to Wildlife Populations and Population Management
Cathy Nowak	Washington State University	Mountain Lion Foraging Ecology
John Johnston	NWRC–Fort Collins	Information Transfer Between Wildlife Services Research (NWRC) and Operations
Kevin Schnorr	Louisiana State University	Infectious Disease Investigations Using Monoclonal Antibodies
Paul Curtis	Cornell University	Technology Applications for Wildlife Management
James Glahn	NWRC–Starkville	Fish-Eating Bird Predation at Aquaculture Facilities: Problem Identification and Control Methods Development
Gwen Stevens	Colorado State University	The Evaluation of an Integrated Bird Hazing System at the Jim Bridger Power Plant–Rock Springs, WY
Ray Sterner	NWRC–Fort Collins	Development of Rodent Repellants
Bruce Bryant	Monell Chemical Senses Center	Pain in a Dish: In Vitro Approaches to Measuring Repellancy
Dale Nolte	NWRC–Olympia	Wildlife Damage to Forest Resources and Bear Damage to Agricultural Resources
Beatriz Villa	National University of Mexico	Rodent Pests in Mexican Sugarcane

MEETINGS, WORKSHOPS, AND CONFERENCE PRESENTATIONS

NWRC scientists make significant efforts to get research information out to the scientific community, customers, clients, and the general public. The following selected activities show both the diverse nature of NWRC's research and its varied stakeholder and interest groups.

Wildlife Service State Meetings—NWRC biologists made numerous presentations on predator management, bird–aquaculture research, bear damage research, and beaver damage to timber resources at various WS State and regional meetings in California, Colorado, Mississippi, Montana, North Carolina, Oregon, South Carolina, Utah, Virginia, West Virginia, and Wyoming.

Wildlife and Their Impacts Workshop—NWRC personnel conducted a 2-day workshop on wildlife and their impacts in Chewelah, WA, in October 1997, at the request of the Washington State University (WSU) Cooperative Extension. Participants were private timber producers looking for feasible approaches to alleviate wildlife damage to forest resources. The workshop provided information to more than 100 individuals on how to identify damage tn forest resources by bears, beavers, birds, deer, elk, jackrabbits, mountain beavers, pocket gophers, porcupines, snowshoe hares, and voles. A general overview of damage control techniques, such as barriers, behavior modification, habitat manipulation, repellants, rodenticides, and traps, was also presented. The workshop included time for the participants to discuss ongoing problems and case studies.

Experimental Aircraft Association Chapter 50 Meeting—A biological technician of the NWRC Sandusky, OH, field station made a presentation entitled "On a Wing and a Prayer, or a Better Way to Avoid Wildlife Strikes" at the monthly meeting of the Experimental Aircraft Association Chapter 50 in Huron, OH, on October 5, 1997. The talk reviewed the consequences involved when aircraft collide with birds and deer and provided information on avoiding such interactions. The importance of completing the FAA Bird and Other Wildlife Strike Report Form was also emphasized.

Wildlife Damage Management for Natural Resource Managers Symposium—The NWRC Olympia field station, the Collaborative Research Team, and the Western Forestry and Conservation Association sponsored a 2-day symposium on wildlife damage management for natural resource managers in October 1997. The symposium presented materials on means to alleviate wildlife damage to forest resources. About 140 participants from 8 States and Canada, representing a variety of State and Federal agencies as well as private companies, attended the event. The first day included sessions on an overview of controls: why they work and how they function and management tools for animal damage. A session on implementing a damage prevention program was followed by field demonstrations and displays.

Displays provided information on the general biology, damage identification and damage management techniques for specific problem animals in the Northwest. Technical experts at each of these displays demonstrated techniques (e.g., problem identification, trapping, barriers) and answered questions. Other displays presented overview information on frightening devices (e.g, effigies, pyrotechnics), barriers, repellants, and supplemental feeding. Technical experts answered questions and offered advice on how and when these techniques could effectively be implemented.

Eighth Eastern Wildlife Damage Management Conference—Biologists from NWRC field stations in Florida, Ohio, and Mississippi attended the eighth Eastern Wildlife Damage Management Conference in Roanoke, VA, in October 1997. They reported on research investigating the use of repellants to control wading-bird damage to commercial ornamental fish farms, electric fences to exclude herons from commercial trout hatcheries, nesting populations of great blue herons and great egrets in the United States and Canada, wildlife-caused losses for commercial catfish producers, and baits to control grackle damage to ripening citrus.

Agriculture Under Secretary Dunn's Visit—Under Secretary of Agriculture Michael Dunn met with staff of the NWRC Hilo, HI, field station and other personnel from WS, Plant Protection and Quarantine, and Veterinary Services on October 31, 1997. Participants toured the facilities, viewed poster displays about field station activities, and were briefed about WS operations and research in Hawaii by WS staff from Honolulu and Hilo.

Ohio State University Students—The NWRC Sandusky, OH, field station and Ohio WS program hosted 16 graduate and undergraduate wildlife biology students from Ohio State University at the 6,000-acre Plum Brook Station on October 10 and November 14, 1997. Students were given instruction in scientific method by collecting data to estimate the size of a deer population. In addition, field demonstrations and lectures on wildlife damage control techniques were provided. Speakers emphasized emerging conflicts between wildlife and people and the integrated research and management programs needed to resolve these conflicts. This is the 13th year the Ohio field station has hosted these field exercises to educate natural resource students about the importance of wildlife damage control as a key component of the wildlife profession.

Predator Seminars—An NWRC scientist from the Logan, UT, field station was invited to present seminars on October 24, 1997, at San Antonio College, TX, and on December 5, 1997, at CSU in Fort Collins. The titles of the presentations, respectively, were "Wolf and Coyote Populations in Yellowstone National Park" and "Social Ecology and Behavior of Coyotes in Yellowstone."

Western Coordinating Committee–95 Annual Meeting— Several NWRC biologists attended the 3-day Vertebrate Pests of Agriculture, Forestry, and Public Lands meeting in November 1997 in Reno, NV. Presentations covered topics on new approaches to reducing gnawing and digging behaviors in the northern pocket gopher and the efficacy of selected commercial deer repellants.

Bird Strike Canada Meeting—A member of NWRC's Sandusky, OH, field station staff attended the 27th annual meeting of the Bird Strike Committee in November 1997 in Ottawa, Canada, where she reported on the status of the U.S. National Bird Strike data base to Committee members and a representative from the International Civil Aviation Organization. This data base, which the Sandusky field station manages for the FAA, contains more than 17,000 records of bird strikes to civilian aircraft in the United States from 1990 to 1997. The Organizaton is incorporating these records into its worldwide data base. Information contained in these data bases is crucial for defining the extent and nature of bird strike problems for airports throughout the world so that corrective actions can be justified and taken.

Colonial Waterbirds Society Annual Meeting—NWRC biologists presented papers on the American white pelican and cormorant foraging and roosting behavior at the Colonial Waterbirds Society Annual Meeting in Lafayette, LA, during November 1997.

Ohio Coordinating Committee for the Control of Depredating Birds Annual Meeting—The staff of the NWRC Sandusky field station presented research findings from 1997 at the annual meeting of the Ohio Coordinating Committee for the Control of Depredating Birds in Columbus, OH, on December 1, 1997. The Committee, which is comprised of representatives from agriculture, the pest control industry, State and Federal agencies, and universities, has met annually since 1965 to discuss vertebrate pest problems in Ohio and to provide direction for research and management efforts.

A major topic of interest to corn farmers at the meeting was an NWRC presentation showing that red-winged blackbird populations had declined 70 percent Statewide from 1966 to 1996. Another major area of discussion regarded the spread of raccoon-strain rabies into Ohio and the newly funded oral-vaccine bait program for the State. In addition, concerns were expressed regarding increased nuisance problems caused by roosting turkey vultures.

Midwest Fish and Wildlife Conference—The 59th Midwest Fish and Wildlife Conference was held in December 1997 in Milwaukee, WI. NWRC presentations included papers on catfish exploitation by double-crested cormorants, the response of invertebrates to herbicide-induced habitat alterations in wetlands, winter home range and habitat use of female ring-necked pheasants in southeastern North Dakota, and nesting populations of double-crested cormorants in the United States and Canada.

Armed Forces Pest Management Board Meeting—NWRC biologists from the Sandusky field station and Fort Collins represented the WS program at the annual meeting of the Armed Forces Pest Management Board held in January 1998 at the USDA Agriculture Research Service (ARS) conference center in Gainesville, FL. This meeting reviews USDA research of interest to the DoD and provides the basis for DoD recommendations to USDA for future research activities. Representatives from ARS and the USDA Forest Service were also present. Overviews of NWRC research activities, an update on BTS research, and findings on research to reduce bird–aircraft collisions at military installations were presented. These presentations specifically related to the use of infrared cameras to monitor deer populations, tall grass management at airports, Canada goose repellent tests, and woodpecker damage management. NWRC presently receives funding from the DoD and FAA for research in these areas.

Sunflower Research Workshop—During the Sunflower Research Workshop held in January 1998 in Fargo, ND, NWRC biologists presented posters on cattail-spraying operations in North Dakota and blackbird densities and sunflower damage in Stutsman County, ND. Workshop attendees were public and private researchers from the United States, France, Brazil, Canada, Belgium, and Australia.

Cormorant Management Workshop—Biologists from NWRC's Mississippi and Ohio field stations participated in a 2-day regional workshop in January 1998 in Glen Falls, NY, to discuss cormorant management in the Northeast. The workshop was sponsored by the Northeast Wildlife Administrators Association in cooperation with WS and the U.S. Fish and Wildlife Service and included various U.S. and Canadian Federal, State, and university administrators and scientists from the Northeast. The workshop focused on biota–natural community impacts, fisheries impacts, and human dimension issues. A proceedings will be issued in 1999 summarizing the presentations by workshop participants and their recommendations relating to future management and research needs.

Fifth Annual Fish Farming Trade Show—Biologists from NWRC's Starkville field station and the Mississippi and Alabama WS operations programs attended the 5th annual fish farming trade show in Greenville, MS, in February 1998. More than 1,000 people from Alabama, Arkansas, Louisiana, and Mississippi attended the show. NWRC and the Mississippi WS State office exhibited a joint poster highlighting an ongoing harassment program to disperse double-crested cormorants from night roosts near fish farms as well as research currently being conducted to alleviate depredations by cormorants, American white pelicans, and wading birds.

Erie, OH, School Presentations—Biologists from NWRC's Sandusky field station presented demonstrations on wildlife research and damage control to about 400 sixth-grade students as part of a 2-day program in conservation education sponsored by the Erie Soil and Water Conservation District. This is the 13th year that personnel from the Ohio field station have cooperated with the District in this event. In these presentations, more than 6,000 students have been introduced to the WS program and the concept of wildlife damage control as an important part of environmental conservation.

Colorado State University Career Fairs—NWRC presented a display highlighting research activities and passed out brochures and pamphlets about WS and NWRC at two CSU career fairs in 1998. The CSU Natural Resources Career Fair was held in February 1998 at the Front Range Student Ecology Symposium. The purpose of the career fair was to provide an informal setting for students to learn more about career options and opportunities within natural-resources-oriented State and Federal agencies and private industries. The Front Range Student Ecology Symposium was held in March 1998 and supported the exchange of information between students and researchers. The displays attracted many people and generated great interest in NWRC's research program.

University of Nebraska at Lincoln Students and Faculty Visit—NWRC hosted 29 students and 2 faculty members from the wildlife program of the University of Nebraska–Lincoln (UN–L) in February. This was UN–L's second field trip to the NWRC in Fort Collins. The current research program of NWRC was detailed for the visitors in briefings, laboratory demonstrations, a field site visit, and a tour of NWRC's indoor Animal Research Building on the Foothills Campus of CSU. Briefings were provided on a wide range of the Center's research topics, including brown tree snakes, prairie dog sterilization and behavior, use of the Internet and the NWRC research library, trap evaluation, Geographic Information System applications, woodpecker repellants, goose–aircraft hazards at Elmendorf Air Force Base, egg oiling, repellants to reduce blackbird damage to rice, immunocontraception in mammals and birds, and the pesticide registration process. Two former M.Sc. graduates of the UN–L program are currently employed by NWRC, and a total of 14 UN–L wildlife graduates are employed throughout the WS program.

Rabies Management Team Meeting—NWRC hosted a 3-day meeting of the Rabies Management Team of WS in Fort Collins in February. The Team is chaired by Denis Slate (WS–New Hampshire) and includes WS representatives from Texas, New York, Ohio, Maryland, Operational Support Staff, and NWRC. The Team invited expert consultants from Cornell University, the Centers for Disease Control and Prevention, the University of Georgia, and from State health departments in New York, Ohio, Texas, and Vermont. The purpose of this important gathering was to discuss oral rabies vaccination and management programs for wildlife rabies in these States, methods and new developments in oral rabies vaccination, and future needs that could be provided by the program. WS will be cooperating with these four State wildlife rabies management and vaccination programs to provide specific wildlife assistance funded by a special congressional appropriation to support this increased involvement in rabies control efforts.

First North American Swift Fox Symposium: Ecology and Conservation of Swift Foxes in a Changing World—NWRC biologists presented papers on the ecology, resource partitioning, and population of the swift fox at this 6-day meeting held in Saskatoon, SK, Canada, in February.

Department of Defense Pest Management Workshop—NWRC's Sandusky field station leader represented NWRC at the DoD Pest Management Workshop at the Naval Air Station, Jacksonville, FL, in February. He made presentations on research related to technologies for bird and wildlife aircraft strike hazard reduction and water and vegetation management on airports to reduce bird hazards. The workshop was attended by 200 military and civilian pest management professionals. Bird strikes cost the U.S. Armed Forces more than $100 million a year.

Rice Technical Working Group—An NWRC biologist gave a presentation on rice seed treatments to deter blackbirds last March at the 27th Rice Technical Working Group in Reno, NV. The Rice Technical Working Group draws an international audience of rice researchers, growers, and other industry members to discuss current rice research, crop production, crop protection, and marketing.

Vertebrate Pest Conference—In March 1998 the 18th Vertebrate Pest Conference was held in Costa Mesa, CA. Highlights of the meeting included a field trip that focused on historical and current wildlife-related disease and urban wildlife issues in the Los Angeles area; the keynote address was presented by NWRC's Richard Dolbeer, who called for scientists in wildlife damage management to base research and management decisions on the population dynamics of target species. NWRC staff presented 21 of the 80 technical papers and participated in a technology exposition that demonstrated innovative computer technologies of possible use in wildlife damage management.

Fourth International Hemorrhagic Fever Conference—An NWRC biologist from Fort Collins attended the fourth quadrennial I nternational Conference on Hemorrhagic Fever with Renal Syndrome and Hantaviruses held in March 1998 in Atlanta. The conference offered paper and poster sessions on a wide variety of topics related to hantavirus epidemiology. A special presentation by NWRC discussed managing rodent populations in hantavirus-endemic areas and emphasized short-term chemical and non-chemical control methods as well as long-term preventative techniques designed to reduce human incidence of disease in rural areas. About 230 participants attended from around the world.

Brown Tree Snake Coordination Committee Meeting—A research biologist from NWRC's Hilo, HI, field station presented an overview of the Center's recent methods development research at a BTS coordination meeting in Honolulu in March. The meeting was attended by representatives of Federal, State, and Territorial agencies involved with the control of this exotic pest species. Presently, WS has operational personnel working on BTS control on the island of Guam, and NWRC scientists are developing chemical techniques for BTS control, both with funding provided by the DoD.

Forest Regeneration and Site Preparation Short Course—An NWRC biologist from Fort Collins conducted portions of a short course over 4 days in March and April at the University of Idaho in Moscow. One of the challenges of reforestation efforts is the damage caused by various mammals. The biologist gave an overview of the general approach to assessing damage, legal aspects of wildlife damage management, and the use of integrated pest management strategies to resolve damage. Using voles, pocket gophers, hares, deer and elk as examples, the biologist reviewed their biology, habitat use patterns, and relations to silvicultural practices. The 30 forest managers in attendance were from Idaho, Montana, Oregon, and Washington and represented several national forests, State forestry departments, Native American tribes, and private forestry companies.

Hawaii Macadamia Nut Association—NWRC biologists presented papers on roof-rat management in macadamia orchards and rat damage-control research in Hawaiian agricultural crops at the 38th Hawaii Macadamia Nut Association Conference held in May in Waikaloa, HI. About 100 industry reprsentatives attended the annual meeting.

Northeast Association of Wildlife Damage Biologists—An NWRC biologist presented a paper entitled "Lethal Control of Piscivorous Birds at Aquaculture Facilities in the Northeast USA: Effects on Populations" at the annual meeting of the Northeast Association of Wildlife Damage Biologists in Camp Hill, PA, last May. Lethal control of fish-eating birds at aquaculture facilities has raised concerns as to the effects on the distribution and abundance of populations of species identified on depredation permits. However, regional and State population trends, as well as model simulations, indicated that the numbers of birds killed under permit at aquaculture facilities had negligible effects on the population status of the respective species. Management recommendations included the continued development of a data base of permit information by the U.S. Fish and Wildlife Service and the use of population modeling in evaluating the effects of planned and implemented programs of lethal control.

Chemical Senses Center Executive Dinner—An NWRC scientist attended the Monell Chemical Senses Center Executive Dinner in May in Philadelphia. His presentation focused on how species-selective response to bitter flavor can be used to reduce pesticide ingestion by nontarget vertebrates. The executive dinner was attended by more than 40 chief executive officers from Government organizations and the medical, food, and fragrance industries.

Catfish Farmers of America—A review of NWRC research on double-crested cormorants was presented to the past and present executive directors of the Ornithological Council and to the executive director of the Catfish Farmers of America at Mississippi State University in May.

Bird Strike Committee–USA Conference—About 320 people attended the eighth annual meeting of the Bird Strike Committee–USA (BSC–USA) at Burke Lakefront Airport, Cleveland, OH, in June. The meeting, which received extensive newspaper and television coverage, was organized by NWRC biologists from Sandusky in cooperation with the city of Cleveland. In all, 25 technical papers and posters were presented on topics related to reducing wildlife collisions with aircraft. A highlight of the conference was the demonstration of 20 techniques for managing wildlife at airports during an all-day field trip to the airport and a nearby gull colony. Fourteen companies exhibited their wildlife management products.

The goal of BSC–USA is to increase communication and professionalism among the diverse groups dealing with wildlife issues at airports, and the 1998 meeting appeared to be highly successful in this regard. The 1999 meeting will be held jointly with Bird Strike Committee– Canada on May 8–12 at the Vancouver [BC] International Airport.

Fertility Control in Coyotes Symposium—In June the NWRC Predation Ecology field station and the Berryman Institute of Utah State University hosted a symposium on fertility control in coyotes, as part of the 79th annual meeting of the Pacific division of the Association for the Advancement of Science. Symposium participants were given guided tours of the field station. About 40 participants representing a variety of organizations, including university professors, scientists and biologists from California, Colorado, Nevada, New Mexico, and Utah, attended. Speakers from the NWRC, Utah Wildlife Services, the Berryman Institute, and the University of Wyoming presented talks on WS operations, applications of contraception to depredation management, the endocrinology of immunocontraception, and possible methods for the oral delivery of contraceptive vaccines.

Western Oregon Forest Protection Association Workshop and Field Tour—An NWRC biologist made a presentation on wildlife impacts on private timber lands in July at the Association meeting in Burnt Woods, OR.

Predation Ecology Field Station Tour—On July 20, NWRC's Predation Ecology field station in Logan, UT, hosted a visit of the American Farm Bureau; Utah and Arizona State legislatures; fish and game officials from Ohio, Arizona, and Utah; and representatives from the Humane Society of the United States, Animal Welfare Institute, Defenders of Wildlife, Rocky Mountain Elk Foundation, and the USDA Cooperative State Research, Education and Extension Service. Field station scientists outlined research activities, and the Utah WS State director discussed the importance of the NWRC to the WS operational program. The visit to the station's Millville research facility was a featured segment of a conference on wildlife damage to agriculture hosted by the Berryman Institute at Utah State University over the next 2 days.

Brown Tree Snake Research Symposium—In July APHIS and the U.S. Geological Survey jointly sponsored the 1998 Brown Tree Snake Research Symposium in Honolulu. This symposium provided opportunities for researchers and managers to discuss research progress on the BTS. Topics included BTS biology; trapping strategies and snake movements; development of attractants, repellants, toxicants, and fumigants; barriers; snake detector dogs; and large-scale control. A concluding session provided managers the opportunity to present their perspectives on research progress and to identify important areas in which further work is needed. More than 100 personnel from research and management agencies (including 15 research and management personnel from WS) participated in the symposium.

International Bird Strike Committee Annual Meeting—A wildlife biologist from the NWRC Ohio field station represented USDA and Bird Strike Committee–USA at the 24th meeting of the International Bird Strike Committee (BSC) in Stara Lesna, Slovakia in September. More than 100 scientists, military personnel, and representatives of the aviation industry from 26 nations met to discuss economic and safety issues related to bird collisions with aircraft. The new USDA–FAA bird strike reporting poster entitled "Strike One—You're Out," which has been distributed to airports in the United States, was displayed and featured on Slovakian television news coverage of the conference. In addition, the employee presented a paper, based on a 7-year study at Kennedy Airport, in New York, comparing the effectiveness of falconry and the shooting of gulls to reduce bird collisions with aircraft. The paper concluded that, although falconry has received considerable positive publicity in the media, there has been no statistical evidence of a reduction in strikes attributed to falconry. In contrast, shooting has received negative publicity but has resulted in a significant reduction in strikes. The speaker reinforced the obligation of scientists to be leaders in ensuring that the public has factual information regarding the effectiveness of wildlife control techniques.

Wildlife Society Annual Meeting—Nine NWRC scientists and two Center-sponsored graduate students attended the Wildlife Society's fifth annual conference in Buffalo, NY, in September. Several NWRC scientists participated in the full-day workshop on the status and future of wildlife fertility control, made six presentations and served on the panel discussion session. The workshop was well attended, and an informative workbook that included abstracts and reprints from scientific literature was provided to participants. In contributed paper sessions, 4 scientists presented 4 papers on carnivore ecology and management, wildlife–airport issues, and the ecological consequences of introduced wildlife species. One scientist moderated a session on wildlife damage and policy and advised students in a special session on Federal employment opportunities. Scientists also participated in Wildlife Society working group meetings and a Rabies Task Force meeting. The conference was attended by more than 1,000 biologists and resource managers from around the world and provided an outstanding forum for interaction.

Australian Vertebrate Pest Conference—An NWRC scientist presented a paper in May entitled "Efficacy of the Methods Used in an Integrated Program To Deter the Dispersal of Brown Tree Snakes from Guam" to this international conference of researchers, managers, and operational personnel involved in reducing wildlife damage. The paper summarized more than 3 years of data on the efficacy of several control methods (trapping, detector dogs, and fenceline searchers) currently used to prevent brown tree snakes from leaving Guam.

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